

★ **COOL TOOLS ISSUE** ★
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Popular Mechanics

TECHNOLOGY SCIENCE HOME IMPROVEMENT DOORS AUTOMOTIVE

50 TOOLS EVERY MAN NEEDS

AND HOW TO USE THEM
LIKE A PRO

*Inside
America's
Biohazard
Super Lab*

★ 10TH ANNIVERSARY

**Jay Leno's
Garage**



THE PM
EVERYTHING TOOL.
WE CAN DREAM,
CAN'T WE? (FOR
THE REAL TOOLS,
SEE P. 76)

**Future-
Proof
Jobs**
& HOW TO
LAND ONE

DIY
Build a
Pergola

Fix Auto
Electrical
Problems

Convert Your
Old Media
To Digital

貴方の中のマスタングが
大和魂を持っている。



Race-prepared vehicle shown.



ドリフトのワールドチャンピオン VAUGHN GITTIN JR. が日本のサーキットを駆け抜ける！
更なる魅力満載な 2010 年型マスタングと貴方の中に眠るレーシング魂を
見つけたい方は THE2010MUSTANG.COM の "THE 10 UNLEASHED" まで今すぐ。



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76

50

Tools We Can't Live Without

This essential gear for cutting, gripping, shaping, pounding—and safety—should be in the workshop of every competent man.

BY LOGAN WARD

92 Paranoid by Design

At the country's newest high-tech laboratory, scientists will attempt to unlock the secrets of Ebola and other deadly infectious diseases. PM tours America's next biosafety hot zone.

BY JOE PAPPALARDO

96 Ten Careers for Right Now

Good times and bad, these next-gen science, tech and engineering jobs show real staying power. Here's how to get a great new gig.

BY CLAIRE MARTIN

102 The Mission

In the 1950s, Nate Saint flew a Piper Cruiser deep into the Amazon jungle of Ecuador to deliver supplies to remote Indian tribes. Now, his son Steve has designed a more versatile vehicle for the job: a DIY dune buggy that can handle tropical roads and, when roads end, soar into the sky.

BY LOGAN WARD

Aircraft restorer Will Lee is currently piecing together a WWII Heinkel 219—the only one left in the world—for the Smithsonian National Air and Space Museum.

ON THE COVER

Harry Allen designed this hypothetical multitool exclusively for POPULAR MECHANICS. Michael Miller built the model; Gregor Halenda photographed it.

Popular Mechanics

PM DEPARTMENTS

NEW TOOLS
CARS
HOME
HOW-TO

"What if we built a boat out of frozen newspapers?"
Jamie Hyneman (left) and Adam Savage, **page 52**.

PM DO-IT-YOURSELF

* TECH WATCH

13 Kepler's Eye NASA's newest space telescope will watch a swath of our galaxy for signs of Earth-like planets. **Plus:** Scientist Meredith Nettles on glacial earthquakes; a moon rock reveals clues about lunar origins.

* UPGRADE

23 Dive Recorder Canon's PowerShot D10 is water-, freeze- and drop-proof. **Plus:** Hand pruners undergo the PM Abusive Lab Test; new ultrawidescreen TVs promise a cinematic home-theater experience.

* NEW CARS

33 Quick Silver The Pontiac Solstice GXP Coupe is a powerful, beautiful blunt instrument. **Plus:** PM's head-to-head test—Infiniti G37 versus Hyundai Genesis Coupe; we drive Audi's 500-plus-hp R8 V10.



* COLUMNS

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48 Jay Leno's Garage In a special **10TH ANNIVERSARY EDITION** of his column, Jay looks ahead instead of back to predict which current cars will become the collectibles of the future.

52 MythBusters Workshop To test a World War II plan to build aircraft carriers out of sawdust and ice, Jamie Hyneman and Adam Savage launch a skiff made of frozen newspapers.

* HOME

109 Building a Backyard Oasis With the right prep work and tools, you can erect the perfect pergola.

112 Staying Cool Amp up central-air-conditioning efficiency and save money.

116 Homeowners Clinic Boost curb appeal with a DIY mailbox post. **Plus:** Brass-polishing tips; getting the deck-railing height right.

* AUTO

121 Saturday Mechanic How to solve electrical problems by chasing voltage drops along the circuit path.

124 Car Clinic Repair plastic fluid tanks in five easy steps. **Plus:** Freezing rust off of stuck fasteners; how to "grease" plastic zippers.

* TECH

128 Ditch Cable, Save Cash Sever the pricey coaxial tether but still have access to your favorite TV shows.

130 Digital Clinic How to digitize and preserve old analog movies and music—the best methods for vinyl, cassettes, VHS and 8 mm. **Plus:** Can you damage your computer's LCD monitor by touching it?

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MIKE LEMISH
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Your duct-tape test was great, but one of the best features of standard duct tape is the ease with which it can be torn if no cutting implement is available. I'm sure you couldn't tear the other tapes as easily, if they can be torn by hand at all. Keep up the great work.

ELLIOT OFSOWITZ
SARASOTA, FL

Policy Reform

As a New Orleans resident and avid visitor of Dauphin Island, I was disappointed by "America's To-Do List" and the comments about reforming flood policies. There is nothing "luxury" about Dauphin Island—the only place for groceries is a gas station. It is home to historic Fort Gaines and a U.S. Coast Guard station. I am positive you could have found a better example of a luxury enclave.

GENE BLANCHARD
NEW ORLEANS, LA

Correction

"Something in the Sky" (March 2009) misidentified military refueling flight paths. The lines represent air-traffic-control boundaries.

PM LETTERS

Seeing and Believing

Just wanted to tell you how much I enjoyed Phil Patton's "Something in the Sky" about UFO sightings and the possible explanations behind them, such as military craft and natural lights. It was refreshing to read your story. Some people will never accept a rational explanation for a UFO sighting—they would rather believe in little green men. I, however, will remain a skeptic.

MIKE KWARCANY
WAUSAU, WI

Your investigation of UFOs can hardly be considered objective. The uninformed would certainly draw the conclusion that virtually all sightings are misidentified aircraft, hoaxes, natural phenomena or the product of crackpots. But how

ISSUE
03/09

Readers responded to an investigation of UFO sightings, a duct-tape test and recommendations for the Obama administration.

do you explain simultaneous visual and radar sightings and reports by airline pilots, police and other credible witnesses? There are many legitimate sightings you could have included to balance out the apparent bias.

S.R. PETOIA
BRICK, NJ

More Tape Abuse

Although your multiuse tape "Abusive Lab Test" was informative, it left out one important criterion: temperature. One cold day when I was sledding and needed duct tape for an emergency, I found it completely useless. It may be a

what
do you
think?

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Online Features

SHED NATION

Once the ground thaws and tulip buds make their first appearance, thoughts turn to the garden—and all eyes turn to the backyard shed. PM has dozens of shed designs, illustrated plans, galleries of the best sheds in America and the



experts' answers to frequently asked questions—such as when you need a permit, how to choose the foundation site, scrapping old sheds, picking the right style and fixing up an eyesore. Go to popularmechanics.com/shednation.



3D AT HOME

A 50-year-old technology makes a resurgence in the home, at the theater and even in National Labs. PM explores the latest new tech behind the emerging 3D trend. popularmechanics.com/digitalhollywood



HARDWARE SHOW

PM heads out to Las Vegas on May 5 to find the best and most innovative tools at the 2009 International Hardware Show. We'll have hands-on reviews and the winners of the Editor's Choice Awards. popularmechanics.com/homejournal

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+ Too Big?

Planets with a mass 10 times that of Earth's grow into gas giants because they have enough gravity to hold onto even the lightest elements: hydrogen and helium.

+ Just Right?

Astronomers are seeking habitable zones where conditions are cool enough to keep surface water from vaporizing, but not so cold that all will be frozen solid.

Kepler's Eye

IS EARTH UNIQUE? A NEW SPACESHIP IS SEEKING PLANETS LIKE OURS TO FIND OUT. BY MARK WOLVERTON

→ **Scientists have found** more than 300 giant planets circling other stars, but finding small and dim Earth-like worlds that could harbor life has been beyond our technology. NASA's Kepler space telescope, scheduled for a March launch, will stare at 100,000 stars in the constellation of Cygnus, watching for the slight dimming that occurs when a planet passes in front of its parent star and blocks out a tiny bit of light. "It's like a flea crawling across a car's headlight," says Kepler program scientist Patricia Boyd. Measuring the dip in brightness and its recurrence can provide data on a planet's size and orbit, statistics vital to determining if life could exist there. Kepler uses the largest mirror ever built for a mission beyond Earth's orbit (shown above). Light from the mirror, hollowed in a honeycomb pattern to reduce weight, is detected by 42 charge-coupled devices, similar to but more sensitive than those in a digital camera.



SHOCKING WAY TO GENERATE VEHICLE POWER

✦ A team of MIT undergraduates has developed a hydraulic shock absorber that generates power. The system forces fluid through a turbine to create electricity. Tests suggest that each shock in a heavy truck could generate about 1 kilowatt of energy, while providing a smoother ride than conventional shocks do.



Pod People of England

Personal Rapid Transit uses small, electric-powered pods to take passengers to specific destinations, with no stops. After years of testing, the idea will finally go live when the ULtra PRT system (above) begins operation at London's Heathrow Airport later this year. Battery-powered electric vehicles will transport people along a 2.7-mile track through the airport's new Terminal 5. The track has been completed, and engineers are now adding charging stations.

DINOSAUR SNAKE HINTS AT PAST CLIMATE

✦ An international team of scientists has uncovered the fossil of a 60-million-year-old snake that weighed 2500 pounds and was more than 40 feet long. Aside from the creep factor, this is significant because the maximum size of cold-blooded animals is determined by temperature. The size of the *Titanoboa cerrejonensis* indicates the South American tropical forest had average temperatures of about 90 F—more than 10 degrees hotter than current norms.

NEWSBRIEFS

Reports From the Edge of Science
Compiled by Alex Hutchinson

Studying Beating Heart Cells Becomes Less of a Stretch

✦ Cardiac muscle cells expand and contract with each heartbeat, and this "stretchiness" makes them difficult to study under realistic conditions in labs. Engineers at Purdue and Stanford universities have developed an elastic electrode by enclosing lines of fluid indium-gallium alloy between two layers of a flexible plastic to create a "liquid wire." Cardiac cells can be grown on top of the electrode, which is then mechanically stretched to simulate heartbeats. The lines of fluid keep electricity flowing even when they're expanded by 40 percent. The technique can also be applied to study neurons deformed in brain trauma.

MACH 3-PLUS OR BUST

✦ Rolls-Royce has started tests of a supersonic turbine engine designed for cruising at speeds above Mach 3. The first of the YJ102R engine's expected uses is in a next-generation cruise missile built by Lockheed Martin. Other possible applications include airplanes and spacecraft.



Moon Rock Solves Mystery

✦ Researchers are analyzing a tiny rock that Apollo astronaut Harrison Schmitt (above) scooped from the moon 36 years ago for clues about the moon's magnetic past. Researchers at MIT determined that the faint magnetic fields in the rock formed over millions of years, suggesting that molten rock was circulating inside the moon's core 4 billion years ago. This supports a theory that the moon was formed by the impact of a Mars-size object crashing into the Earth.



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PM INTERVIEW
ICEQUAKE DETECTIVE

Meredith Nettles

A scientist tracks Greenland's collapsing glaciers as they rattle seismographs.

She is a geophysicist with an eye for unusual earthquakes. In 2003, Meredith Nettles and several colleagues noticed an epidemic of bizarre earthquakes emanating from a geologically unlikely spot: the coasts of Greenland. The team found that the quakes were caused by glaciers moving so violently that they registered on seismic recordings. Nettles, a professor at Columbia University's Lamont-Doherty Earth Observatory, is now conducting field studies to learn more about glacier dynamics.

Q What are glacial earthquakes, and what causes them?

A The signal comes from the collapse of a large mass of ice off the end of a glacier. The largest determinant of changes in speed for Greenland's outlet glaciers comes from what's happening at the calving front. You lose this ice off the front and that reduces resistance, so the whole glacier speeds up. Then, because the speed-up is bigger at the front of the glacier, the ice stretches and becomes thinner. That can make the calving rate increase. So now you've sped up the process that made the glacier go faster. It's a positive feedback cycle.

Geophysicist Nettles installs a GPS unit on Greenland's Helheim Glacier to track ice movement. Researchers have seen a peak speed of about 7 miles per year.

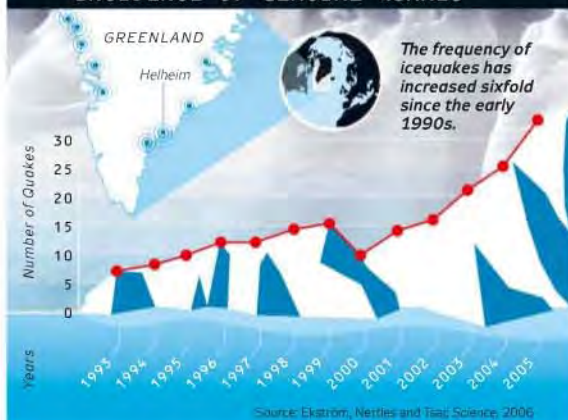
Q Have you witnessed a glacial earthquake happening in person?

A We saw a couple last summer, from our helicopter. We were at the outlet to the Helheim Glacier, in a system of fjords with sheer rock walls that are more than 1500 feet tall. Typically, you start to see a rift open up in the glacier, and then this big block of ice starts to roll over. It might be a couple of miles long, and it's the full thickness of the glacier, which is about 2300 feet—mainly underwater—and then it stretches maybe a quarter-mile up the glacier. So it's easily a cubic kilometer [35 billion cubic feet] of ice. Then you see just tons of water streaming off of the new iceberg.

Q What does your research imply for sea-level rise?

A If you look at the most recent Intergovernmental Panel on Climate Change report, rapid changes in glacier dynamics are not taken into account in the predictions of sea-level rise because not enough is known about those processes. But what we have seen during the last decade are very rapid changes in glacier flow speeds, very rapid retreats of the glacier terminus and very rapid thinning of the outlet glaciers. And those things put ice into the ocean faster. So understanding how glaciers respond dynamically to environmental conditions is important. That's the unknown. — INTERVIEWED BY JERRY BEILINSON

INCIDENCE OF GLACIAL QUAKES



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†Tires must be purchased from a Bridgestone retailer's inventory between April 4 and May 2, 2009. Mail-in claim form required. Restrictions and limitations apply. See your participating Bridgestone retailer for complete details.

Big Projects, Big Waste

● BY JOE PAPPALARDO

THE PENTAGON AND NASA SELDOM SEE A BUDGET THEY CAN'T BUST—THEIR AVERAGE COST OVERRUN IS NOW 26 PERCENT AND IS GETTING WORSE. BUT THE SYSTEM CAN BE FIXED, SAYS CONSULTING FIRM DELOITTE AEROSPACE & DEFENSE, IF CONTRACTORS, POLITICIANS AND OFFICIALS CAN LEARN FROM PAST MISTAKES.

1 Supply Chains Are Hopelessly Tangled

Space and defense contractors have long relied on networks of subcontractors to make critical parts. But in recent years, they have offloaded more work to their suppliers—forcing those smaller companies to develop sophisticated technology. That has advantages, but more links in the chain can also mean more delays or mistakes—and an error from a single supplier can derail an entire project.

Deloitte's Fix: Big firms should exercise more oversight of suppliers and delegate a supply-chain "architect" to integrate the entire job.

2 Big Contractors Lowball Time and Cost

Large aerospace firms often promise overly optimistic timelines, sincere or feigned, to win a contract bid. Then, when the firms do not deliver and costs rise, Congress may cut back on the total order, causing the cost per item to skyrocket. Further, money from well-run programs is often rerouted to troubled ones, creating a domino effect of inefficiency and delay.

Deloitte's Fix: Set hard milestones and scout potential problems from the start; build more slack into timetables to account for unforeseen problems.

3 Officials and Engineers Lack Critical Experience

NASA builds fewer spacecraft these days, denying young engineers valuable experience that might instill healthy skepticism. Modern missions rely on new technology, but inexperienced staff may only see the promise and not the risk. (The same is true in the defense industry, where contractors build fewer—though more pricey—systems.)

Deloitte's Fix: Retain baby-boomer engineers and technicians with incentives; create mentorships for students; finalize contracts after suppliers prove their tech actually works as needed.

Case Studies



Expeditionary Fighting Vehicle

COST

\$13 billion

→ The EFV is a Marine Corps amphibious assault vehicle that can be launched from a ship and then driven on land. The design changed during development, but General Dynamics neglected to deliver the new plans to its subcontractors.

The unsurprising result: Expensive parts didn't fit together. After 10 years, the Marines got a craft that leaks, breaks down an average of about once every 4.5 hours and sometimes veers off course.



F-22 Raptor

COST

\$65 billion

→ Lockheed Martin and Boeing, who teamed up to create this stealth warplane, entered production with only about half the critical manufacturing processes in place. Canopies cracked while they were being installed, and the overall rework and repair rate of the

first airplanes was 30 percent. Rising costs are one reason the Air Force is buying far fewer F-22s, but that bumps up the cost per airplane to about \$140 million.



Mars Science Laboratory

COST

\$2.2 billion

→ The Mars Science Lab now under construction is the largest rover ever designed to explore another planet, and it will use nuclear power to do it. After years of development, engineers shelved advanced gearboxes they'd originally planned,

starting a chain reaction of redesign of other moving parts. The resulting delay caused mission planners to miss their launch window, and they must now wait until 2011. NASA officials say they "underestimated what it was going to take" to build the new rover.



**"I'm taking an antidepressant,
but I think I might need more help."**

Approximately 2 out of 3 people being treated for depression still have depression symptoms. If an antidepressant alone isn't enough, talk to your doctor. Your options may include **adding ABILIFY to the antidepressant you're already taking.**

ABILIFY is FDA-approved to treat depression in adults when added to an antidepressant (such as Lexapro®, Zoloft®, Prozac®, Effexor XR® or Paxil CR®).*

IMPORTANT SAFETY INFORMATION:

Elderly patients with dementia-related psychosis (eg, an inability to perform daily activities due to increased memory loss) taking ABILIFY have an increased risk of death or stroke. ABILIFY is not approved for treating these patients.

Antidepressants can increase suicidal thoughts and behaviors in children, teens, and young adults. Serious mental illnesses are themselves associated with an increase in the risk of suicide. When taking ABILIFY call your doctor right away if you have new or worsening depression symptoms, unusual changes in behavior, or thoughts of suicide. Patients and their caregivers should be especially observant within the first few months of treatment or after a change in dose. Approved only for adults 18 and over with depression.

- Alert your doctor if you develop very high fever, rigid muscles, shaking, confusion, sweating, or increased heart rate and blood pressure, as these may be signs of a rare but potentially fatal condition called neuroleptic malignant syndrome (NMS)
- If you develop abnormal or uncontrollable facial movements, notify your doctor, as these may be signs of tardive dyskinesia (TD), which could become permanent
- If you have diabetes or have risk factors or symptoms of diabetes, your blood sugar should be monitored. High blood sugar has been reported with ABILIFY and medicines like it. In some cases, extreme high blood sugar can lead to coma or death
- Other risks may include lightheadedness upon standing, seizures, trouble swallowing, or impairment in judgment or motor skills. Until you know how ABILIFY affects you, you should not drive or operate machinery

The common side effects in adults in clinical trials ($\geq 10\%$) include nausea, vomiting, constipation, headache, dizziness, an inner sense of restlessness or need to move (akathisia), anxiety, and insomnia. Tell your doctor about all the medicines you're taking, since there are some risks for drug interactions. You should avoid alcohol while taking ABILIFY.

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch, or call 1-800-FDA-1088.

Please read the Important Information about ABILIFY on the adjacent page.

* Lexapro® (escitalopram oxalate), Zoloft® (sertraline HCl), Prozac® (fluoxetine hydrochloride), Effexor XR® (venlafaxine HCl), Paxil CR® (paroxetine HCl) are trademarks of their respective companies.

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Partnership for
Prescription Assistance



IMPORTANT INFORMATION ABOUT ABILIFY

This summary of the Package Insert contains risk and safety information for patients about ABILIFY. This summary does not include all information about ABILIFY and does not take the place of discussions with your healthcare professional about your treatment. Please read this important information before you start taking ABILIFY and discuss any questions about ABILIFY with your healthcare professional.

Name

ABILIFY® (a-BIL-i-fi) (aripiprazole) (air-ri-PIP-ra-zoll)

What is ABILIFY?

ABILIFY (aripiprazole) is a prescription medicine used as an add-on treatment to antidepressants for Major Depressive Disorder in adults.

What is depression?

Depression is a common but serious medical condition. Symptoms may include sadness, loss of interest in activities you once enjoyed, loss of energy, difficulty concentrating or making decisions, feelings of worthlessness or excessive guilt, insomnia or excessive sleep, a change in appetite causing weight loss or gain, or thoughts of death or suicide. These could be depression symptoms if they interfere with daily life at home, at work, or with friends and last most of the day, nearly every day for at least 2 weeks.

What is the most important information that I should know about antidepressant medicines, depression, and other serious mental illnesses?

- Antidepressant medicines may increase suicidal thoughts or actions in some children, teenagers, and young adults
- Depression and serious mental illnesses are the most important causes of suicidal thoughts and actions

For more information, see the Prescribing Information and the Medication Guide called *Antidepressant Medicines, Depression and Other Serious Mental Illnesses, and Suicidal Thoughts or Actions*.

Who should NOT take ABILIFY?

People who are allergic to ABILIFY or to any substance that is in it. Allergic reactions have ranged from rash, hives and itching to difficulty breathing and swelling of the face, lips, or tongue. Please talk with your healthcare professional.

What is the most important information that I should know about ABILIFY?

Elderly patients, diagnosed with psychosis as a result of dementia (for example, an inability to perform daily activities as a result of increased memory loss), and who are treated with antipsychotic medicines including ABILIFY, are at an increased risk of death when compared to patients who are treated with a placebo (sugar pill). ABILIFY is not approved for the treatment of patients with dementia-related psychosis.

Antidepressants may increase suicidal thoughts or behaviors in some children, teenagers, and young adults, especially within the first few months of treatment or when the dose is changed. Depression and other serious mental illnesses are themselves associated with an increase in the risk of suicide. Patients on antidepressants and their families or caregivers should watch for new or worsening depression symptoms, unusual changes in behavior, or thoughts of suicide. Such symptoms should be reported to the patient's healthcare professional right away, especially if they are severe or occur suddenly. ABILIFY is not approved for use in pediatric patients with depression.

Serious side effects can occur with any antipsychotic medicine, including ABILIFY. Tell your healthcare professional right away if you have any conditions or side effects, including the following:

Stroke or ministroke in elderly patients with dementia: An increased risk of stroke and ministroke has been reported in clinical studies of elderly patients with dementia (for example, increased memory loss and inability to perform daily activities). ABILIFY is not approved for treating patients with dementia.

Neuroleptic malignant syndrome (NMS): Very high fever, rigid muscles, shaking, confusion, sweating, or increased heart rate and blood pressure may be signs of NMS, a rare but serious side effect that could be fatal.

Tardive dyskinesia (TD): Abnormal or uncontrollable movements of face, tongue, or other parts of body may be signs of a serious condition known as TD, which may be permanent.

High blood sugar and diabetes: Patients with diabetes and those having risk factors for diabetes (for example, obesity, family history of diabetes), as well as those with symptoms such as unexpected increases in thirst, urination, or hunger should have their blood sugar levels checked before and during treatment. Increases in blood sugar levels (hyperglycemia), in some cases serious and associated with coma or death, have been reported in patients taking ABILIFY, and medicines like it.

Orthostatic hypotension: Lightheadedness or faintness caused by a sudden change in heart rate and blood pressure when rising too quickly from a sitting or lying position (orthostatic hypotension) has been reported with ABILIFY.

Suicidal thoughts: If you have suicidal thoughts, you should tell your healthcare professional right away.

Dysphagia: Medicines like ABILIFY have been associated with swallowing problems (dysphagia). If you had or have swallowing problems, you should tell your healthcare professional.

What should I talk to my healthcare provider about?

Patients and their families or caregivers should watch for new or worsening depression symptoms, unusual changes in behavior and thoughts of suicide, as well as for anxiety, agitation, panic attacks, difficulty sleeping, irritability, hostility, aggressiveness, impulsivity, restlessness, or extreme hyperactivity. Call your healthcare provider right away if you have thoughts of suicide or if any of these symptoms are severe or occur suddenly. Be especially observant within the first few months of antidepressant treatment or whenever there is a change in dose.

Tell your healthcare provider about any medical conditions you may have and all medicines that you are taking or plan to take, including prescription and nonprescription (over-the-counter) medicines.

Be sure to tell your healthcare provider:

- If you have suicidal thoughts
- If you or anyone in your family have or had seizures
- If you or anyone in your family have or had high blood sugar or diabetes
- If you are pregnant, plan to become pregnant, or are breast-feeding

What should I avoid when taking ABILIFY (aripiprazole)?

- Avoid overheating and dehydration
- Avoid driving or operating hazardous machinery until you know how ABILIFY affects you
- Avoid drinking alcohol
- Avoid breast-feeding an infant

What are the possible side effects of ABILIFY?

Common side effects in adults include: nausea, vomiting, constipation, headache, dizziness, an inner sense of restlessness or need to move (akathisia), anxiety and insomnia.

It is important to contact your healthcare professional if you experience prolonged, abnormal muscle spasm or contraction which may be signs of a condition called dystonia.

What percentage of people stopped taking ABILIFY due to side effects?

In clinical trials, the percentage of adults who discontinued taking ABILIFY due to side effects was ABILIFY (6%) and for patients treated with sugar pill (2%).

Can I safely take ABILIFY while I'm taking other medications?

ABILIFY can be taken with most drugs; however, taking ABILIFY with some medicines may require your healthcare professional to adjust the dosage of ABILIFY.

Some medicines* include:

- ketoconazole (NIZORAL®)
- quinidine (QUINIDEX®)
- fluoxetine (PROZAC®)
- paroxetine (PAXIL®)
- carbamazepine (TEGRETOL®)

It is important to tell your healthcare professional about all the medicines you're taking, just to be sure.

General advice about ABILIFY:

- ABILIFY is usually taken once a day, with or without food
- ABILIFY should be kept out of the reach of children and pets
- Store ABILIFY Tablets and the Oral Solution at room temperature
- For patients who must limit their sugar intake, be aware that ABILIFY Oral Solution contains sugar
- For patients who cannot metabolize phenylalanine (those with phenylketonuria or PKU), ABILIFY DISCMELT® contains phenylalanine
- If you have additional questions, talk to your healthcare professional

Find out more about ABILIFY:

Additional information can be found at www.abilify.com

* NIZORAL is a registered trademark of Janssen Pharmaceutica; QUINIDEX is a registered trademark of Wyeth Pharmaceuticals; PROZAC is a registered trademark of Eli Lilly and Company; PAXIL is a registered trademark of GlaxoSmithKline; TEGRETOL is a registered trademark of Novartis Pharmaceuticals.

Based on Full Prescribing Information as of 05/08 1239550A2.

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Tablets manufactured by Otsuka Pharmaceutical Co., Ltd., Tokyo, 101-8535 Japan or Bristol-Myers Squibb Company, Princeton, NJ 08543 USA.
Orally Disintegrating Tablets, Oral Solution, and Injection manufactured by Bristol-Myers Squibb Company, Princeton, NJ 08543 USA.
Distributed and marketed by Otsuka America Pharmaceutical, Inc., Rockville, MD 20850 USA.
Marketed by Bristol-Myers Squibb Company, Princeton, NJ 08543 USA.
U.S. Patent Nos. 5,006,528; 6,977,257; and 7,115,587.

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570US08CBS01601 0308L-1141 Printed in USA D6-B0001D-05-08-MDD May 2008

One Shot, One Kill, Zero Pilot

A NEW UNMANNED
HELICOPTER BRINGS
FINESSE TO AIRSTRIKES.
BY DAVID HAMBLING

→ In modern warfare, the advantage often goes to guerrillas who can attack, then quickly hide among the population or disappear into the hills. To counter those tactics, the Pentagon since 2001 has been arming unmanned aerial vehicles to identify and destroy targets with missiles. The Defense Department is seeking weapons for UAVs that can strike enemies but limit collateral damage, especially in cities.

The Army's solution is the Autonomous Rotorcraft Sniper System (ARSS), a small, unmanned helicopter equipped with a powerful .338-caliber rifle. An autopilot system handles the tricky business of flying while the operator lines up the kill shot on a remote monitor.

The Army ground-tested the rifle's

turret on a Vigilante unmanned helicopter to evaluate its accuracy. The turret-control hardware and flight-control algorithms will be refined to make shots more accurate before airborne testing begins in July. The program's heads say the airborne robo-sniper idea was put forward five years ago, but only became practical when Utah State University's Space Dynamics Laboratory designed a lightweight, stabilized turret. Users control it with an adapted Xbox 360 controller. The same turret could be used on unmanned fixed-wing aircraft such as the Predator or Reaper and could also allow ground robots to fire on the move.

Vigilante 502 Unmanned Helicopter

- + Max Weight: 1100 pounds
- + Length: 26 feet
- + Rotor Diameter: 23 feet
- + Top Speed: 117 mph
- + Payload: 150 pounds
- + Fuel Capacity: 36 gallons
- + Flight Time: 6-plus hours

RND Manufacturing Edge 2000 Rifle

- + Cartridge: Lapua Magnum .338
- + Weight: 14 pounds
- + Action: Gas-operated semiautomatic
- + Muzzle Velocity: 3000 feet per second with 250-grain bullet
- + Rate of Fire: Up to 10 carefully aimed shots per minute
- + Ammunition Cost: \$4 per round

Other Possible Weapons for the ARSS

- + M249 5.56-mm squad automatic weapon, a small-caliber machine gun
- + M240 7.62-mm machine gun, a weapon used by the U.S. and NATO
- + AA-12 12-gauge, a full-auto shotgun
- + Peak Beam Immobilizer, a xenon strobe light that stuns targets with "psycho-physical" effects like disorientation and nausea



Time
Machine
JANUARY
1953



POPULAR MECHANICS has always covered advances in tool technology. In January 1953, the magazine pulled together the best DIY implements every home should have in "Shopping for Tools," covering everything from an adjustable clamp to a water-cooled diamond drill that could "cut through masonry, glass or porcelain at the rate of 1 inch every few seconds." Some classic tools have barely changed since then, while others have been transformed: The portable electric sander of 1953 gave way to random-orbit models that collect their own sawdust and work with precut, peel-off abrasive sheets. And hex-shank multibit screwdrivers? Those are new. (See "50 Tools We Can't Live Without," page 76.) — ALLIE HAAKE



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Upgrade

The **Canon PowerShot D10** is one of a new breed of ruggedized and waterproof compact cameras.

Dive Recorder

Canon is known as a cautious company, typically eschewing glitzy features and instead focusing on basics such as improving image sensors and lens glass. And while waterproof and ruggedized cameras have been around for years, the camera maker has steered clear—until now. The 12.1-megapixel, 3x-optical-zooming **Canon PowerShot D10 (\$330)** is the company's first waterproof camera, and one of the toughest we've seen—it can be submerged 33 feet, fall 4 feet and withstand temperatures as cold as 14 F. And yeah, we kind of dig the Jacques Cousteau-esque casing. —SETH PORGES

When shown in their original format on standard definition or HDTVs, most movies only play in the black area.



Future Watch

ULTRAWIDE TVs

Next to a boxy tube, all HDTVs are widescreen. But use a plasma to watch a movie in its original format and often you still have to deal with pesky black letterboxing bars on the top and bottom of the screen. The reason: Movie theaters typically have an aspect ratio of roughly 21:9 (meaning that for every 21 inches the picture is wide, it's 9 inches tall), while an HDTV's is just 16:9. But those black bars could soon disappear. The new **Philips Cinema 21:9** is the first TV to replicate the ultrawide aspect ratio of a theater. Philips hasn't announced U.S. availability just yet (the set is coming to Europe this spring), but we expect a similar set to hit the States this year.



High-Tech Beam

The 70-lumen LED Energizer Hard Case Tactical 2AA Second Generation Handheld Light (price not set) is waterproof and can survive 15-foot falls. It has an infrared light for night-vision gadgets, as well as tiny red, green and blue LEDs that can be used for map-reading and medical applications. But its best feature? If you're short a battery, it can still produce a (dimmer) beam with a single AA.

Goodbye Gas

The **Vectrix VX 1 Scooter (\$10,495)** isn't the first all-electric two-wheel vehicle, but it is the first that's highway-legal—it has a top speed of about 62 mph, accelerates from 0 to 50 in under 7 seconds, and has a range of up to 55 miles per charge.





CG Utility



CG Padded Palm



CG Impact Pro

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Abusive Lab Test

BYPASS PRUNERS

Bypass hand pruners, designed to cut branches less than 1 inch wide, often snip more than stems. They slice rope, twine and even chicken wire—or at least, the ones in our test did. Unfair? Maybe—but the results were revealing. And, yes, shrubbery was harmed in the making of this report. *BY HARRY SAWYERS*



Celery's fine structure showed how cleanly a blade could cut. Twine and chicken wire dispensed abuse.

PRECISION

Clean cuts help plants heal. We snipped celery and shrubs—then peered closely.

SHARPNESS

How sharp is sharp? For a hard test, we sliced $\frac{3}{8}$ -inch nylon/poly rope and No. 18 mason's twine.

DURABILITY

We cut blade-dulling chicken wire, then sliced more celery to judge the abused blades' precision.

Felco 12
(\$55)

Felco's handle rotates for easy squeezing, but it has too much play and is difficult to keep under control. It cleanly cut our celery and branches.

These weren't the sharpest blades of the batch—they took the most effort to slice twine, and left the rope with frayed edges that made it look like it'd been cut with a saw.

While chicken wire left the other pruners chipped and dull, the Felco's blades proved durable, surviving with little damage. But celery cuts were more ragged after the wire.



Fiskars PowerGear 7936
(\$28)

The handle's force-multiplying gear allowed us to make more cuts without tiring our hands. But the blades hacked the celery and crushed stem edges.

While these pruners didn't cut the rope cleanly, they didn't jam and were easy to squeeze. Twine snipped with two cuts or by twice dragging the line over the open blade.

The chicken wire proved most damaging to the Fiskars—We could feel each agonizing crunch as the blades bit through the metal mesh links. The celery, obviously, suffered.



A.M. Leonard 1286
(\$25)

The test's most precise cutter was also the least powerful—its blades made the smoothest celery slices, but had a tough time biting branch bark.

This was the sharpest tool we tested—the blade bifurcated the twine in a single pass. And while chopping rope took several squeezes, the blades left the cleanest cut.

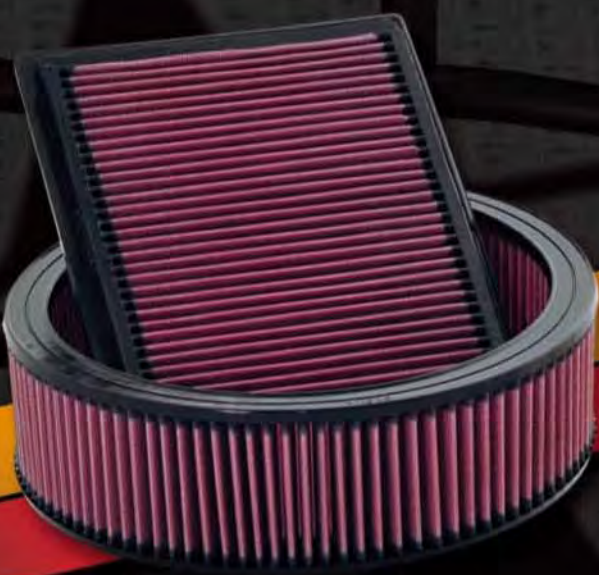
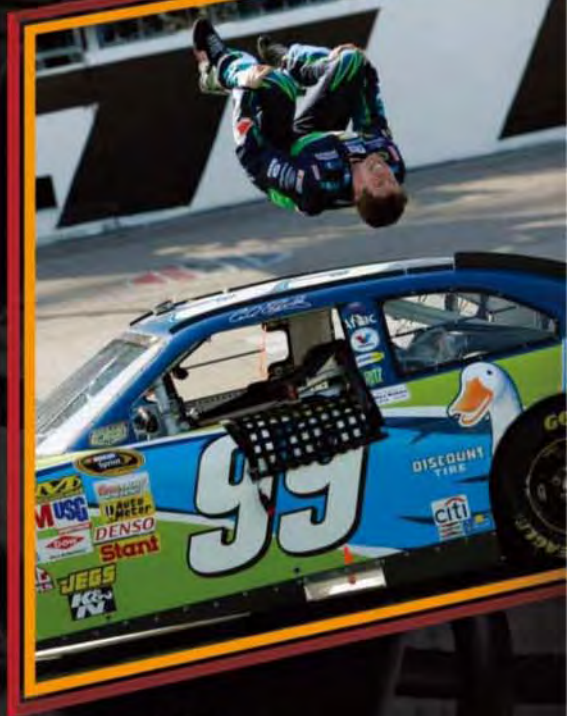
Although the A.M. Leonards seemed to chomp through the wire with ease, a postmortem examination revealed the blades had taken considerable damage.

BOTTOM LINE

Fiskars' pruners cut with the least effort, and no tool could top Felco's blade durability. But the best all-around performer was also the least expensive: A.M. Leonard's 1286.



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 Performing a backflip in the infield is taking a chance.
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Wrist-Top Widescreen

In order to see all that a full-featured sports watch has to offer, users typically need to scroll through various modes. The **Timex Expedition WS4 Watch (\$200)** has an enormous wide-screen face that allows it to display an altimeter, barometer, thermometer, chronograph and compass, all at once.



Take Two

On the outside, the differences between the new **Nintendo DSi (\$170)** game system and the older Nintendo DS are slight—a few rearranged buttons and a built-in camera for taking goofy pictures. The real reason to upgrade: The new system boasts access to a storefront that allows users to download low-priced games over Wi-Fi.

Test Drive

ROOFTOP
CARGO
CARRIER

Once you've filled your car's interior with road-trip gear, there's nowhere to go but up. And most rooftop cargo carriers go way up—often adding 14 to 18 inches of drag-inducing height to a vehicle. I recently packed the 15-cubic-foot **Yakima SkyBox LoPro Titanium (\$700)** for a week-end's worth of driving. Its 11.5-inch height (the lowest we've seen) minimized drag, kept wind noise down and caused no problems in low-clearance garages. —GLENN DERENE

A solar panel charges the SkyBox's LED lights, which automatically turn on when the cargo box is opened.



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ACTUAL
SIZE

Reader Refresh

The Amazon Kindle wasn't the first e-book reader—electronic books have been around in one form or another since the 1990s—but it was the product that brought the category into the mainstream. Despite an awkward design, the Kindle's integrated 3G cellular access, E Ink screen and huge selection of downloadable books turned the device into a hit. The **Amazon Kindle 2 (\$360)** refines the original. It's much thinner, slightly faster, and easier to use. Not a reinvention, but a smart second act.



The Kindle 2's screen refreshes 20 percent faster than the original's. Unlike its competitors, this Kindle has no touch-screen—onscreen selection is done using a joystick.

The Kindle 2's biggest improvements are ergonomic. With a depth of 0.36 inches, it's one of the thinnest gadgets of any kind, and about half as thick as its predecessor.

The Kindle 2's 2 GB of internal memory is more than seven times its predecessor's onboard capacity. Good thing, too—the second-gen Kindle lacks the original's SD-card expansion slot.



The standard way to hide home theater wires: Charge up a drill and start punching holes in the drywall. The **FlatWire HDMI Cable (price not set)** offers an alternative. It is basically a steamrolled HDMI cable—it looks more like a piece of drywall tape than like high-bandwidth digital cable. Making it disappear is as easy as sticking it to a wall, mudding it and painting.

Svelter Shelter

Typical three-season, four-person car-camping tents weigh 10 to 20 pounds—too heavy to double as backcountry shelters. The **Sierra Designs Lightning XT 4 Tent (\$450)** is spacious enough for road warriors (it has 57.5 square feet of surface space and a peak height of 49 inches), but it weighs just 6 pounds 13 ounces, thanks to clever pole geometry. That's not bad for short-haul hiking.



Remote Control

For years, Slingbox set-top box users have been able to watch and control all their home TV channels from Web-enabled computers and phones. But until now, this place-shifting magic has required a separate box. Not anymore—satellite TV provider EchoStar recently purchased the Slingbox's manufacturer. The brainchild of this union: the *Dish Network VIP 922 SlingLoaded HD DuoDVR* (price not set), the first DVR to feature Slingbox-like functionality. One caveat—it works only with Dish Network satellite subscriptions.



A More Noble Gas

Propane is cleaner-burning than gasoline and is better able to endure an idle winter in the shed. But until now, it has been absent from handheld yard tools—a shame, considering two-stroke gas-guzzlers are notorious polluters. The reason: It's hard to engineer a propane engine that can be turned upside down. The *Craftsman Propane Weedwacker*, powered by LEHR (\$200), which runs off 16.4-ounce canisters, is the first. The string trimmer's four-stroke engine emits a fraction of the pollution of a two-stroke gas motor. Next up could be a leaf blower.

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Read details below.

The Fifth C?

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Is it possible that the mind of a scientist can create more beauty and romance than Mother Nature? The laboratories at DiamondAura® were created with one mission in mind: *Create brilliant cut jewelry that allows everyone to experience more clarity, more scintillation and larger carat weights than they have ever experienced.* So, we've taken 2 ½ carats of our lab-created DiamondAura® and set them in the most classic setting—the result is our most stunning, fiery, faceted design yet! In purely scientific measurement terms, the refractory index of the DiamondAura is very high, and the color dispersion is **actually superior** to mined diamonds.

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	Mined Flawless Diamond	DiamondAura® Compares to:
Hardness	Cuts Glass	Cuts Glass
Cut (58 facets)	Brilliant	Brilliant
Color	"D" Colorless	"D" Colorless
Clarity	"IF"	Clear
Dispersion/Fire	0.044	0.066
2 ½ c.t.w. ring	\$60,000+	\$145

process, but will only say that it involves the use of rare minerals heated to an incredibly high temperature of over 5000°F. This can only be accomplished inside some very modern and expensive laboratory equipment. After several additional steps, scientists finally created a clear marvel that looks even better than the vast majority of mined diamonds. According to the book *Jewelry and Gems—the Buying Guide*, the technique used in DiamondAura offers, "The best diamond simulation to date, and even some jewelers have mistaken these stones for mined diamonds."

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Rock solid guarantee. This .925 sterling silver ring is prong-set with a 1 ½ carat DiamondAura round brilliant in the center, showcased between two DiamondAura round brilliants of ½ carats each. Adding to your 4 C's, we will include the DiamondAura stud earrings for FREE! Try the DiamondAura 3-Stone Classique Ring for 30 days. If for any reason you are not satisfied with your purchase, simply return it to us for a full refund of the purchase price and keep the stud earrings as our gift.

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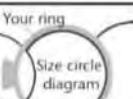
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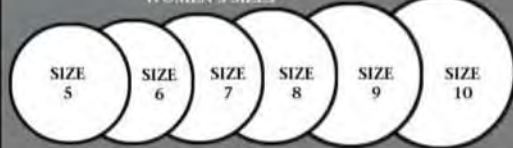
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SUPERCAR + HYBRID



New Cars

++ PM TEST DRIVEN

Quick Silver

Pontiac's \$30,995 Solstice GXP Coupe is a bit like a bush league version of the Corvette. It's powerful, it's downright gorgeous from any angle, and it corners flat. But refined? Not so much. Unlike the Corvette, the smaller GXP Coupe struggles to be practical. The interior lacks much usable storage. There's only 5.6 cubic feet of cargo space in the hatch—enough for a weekend-size suitcase. And the visibility for

the driver isn't exactly reminiscent of a crossover's. It's cramped, too. The GXP Coupe is a blunt performance instrument—like an old-school muscle car. The direct-injected 260-hp turbocharged four-cylinder and five-speed manual provide enough thrust to hit 60 mph in around 5.3 seconds. Better still, you can hear the faint whoosh of the turbo as you accelerate and grab a fistful of shifter for the next gear. The GXP will do big smoky burnouts—as any good Pontiac should. The result is a car that's fun to drive but not so easy to live with. —BEN STEWART

+ INSIDE

Honda DN-01 > Audi R8 5.2 FSI Quattro >
Volvo XC60 > Toyota Prius

+ PONTIAC SOLSTICE GXP COUPE



PM TEST
DRIVEN

→ Pontiac Solstice GXP Coupe | Honda DN-01 |
 Audi R8 5.2 FSI Quattro | Volvo XC60 | Toyota Prius X



1 2009 Honda DN-01

2 2010 Audi R8 5.2 FSI Quattro

Future Cruiser

The 595-pound DN-01 is a two-wheeled crossover of sorts—part cruiser, part scooter. At the heart of this bike is a 680-cc V-twin paired to a unique automatic transmission that shares elements with a Honda ATV. It provides two fully automatic shift programs along with a manually operated six-speed mode for sporty riding. On our weeklong ride around L.A., the \$14,599 DN-01 delivered a solid 44 mpg. And it's remarkably easy to ride. It has none of the overwhelming mass one might expect for a bike this size, so you can maneuver the DN-01 confidently at low speeds. Still, the transmission system can't help but lend a slightly appliance-like feel if you're used to a traditional motorcycle.

—BARRY WINFIELD

Top Gun

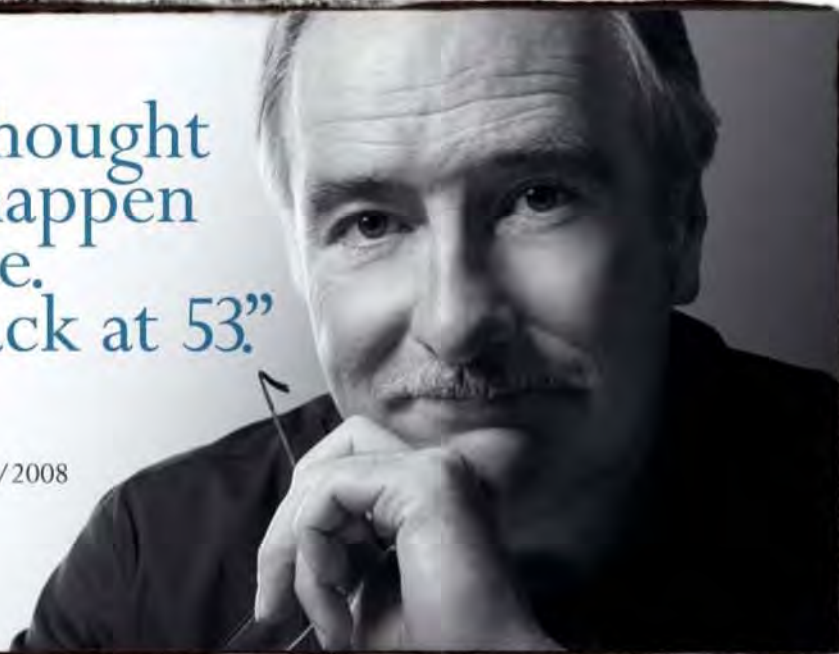
The R8 didn't need much to join the top-tier supercar ranks. The road rocket nearly had it all—a lightweight aluminum structure and body, midengine layout, all-wheel drive and a design that left bystanders, well, lusting for another look. The missing piece has just been added—a 525-hp version of Lamborghini's V10. The aluminum motor spins to a hair-raising 8700 rpm, resulting in a frighteningly fast 88.3-feet-per-second maximum piston speed. Upshifts pin you to the seat as the car gallops forward, inhaling ever longer stretches of pavement as the engine howls. We could do this all day. It's certainly a firm-riding car, but the payoff is Ginsu-like handling precision. Perhaps the best part is the fact that the car has lost none of its civility in its high-horsepower transformation. It's as comfortable as it is quick.

—LARRY WEBSTER

We hauled our VBox GPS test gear to Marbella, Spain, to test a \$190,000 R tronic-equipped 5.2-liter V10 R8. We clocked the V10 R8 to 60 mph in only 3.81 seconds. It cleared 100 mph in 8.41 seconds and passed the quarter-mile in 11.80 seconds at 119.5 mph. That's Corvette ZR1 territory. Woof.

"I never thought
it could happen
to me.
A heart attack at 53."

~Steve A.
New York, NY
Heart attack: 1/9/2008



"I had been feeling fine. But turns out my cholesterol and other risk factors* increased my chance of a heart attack. Now I trust my heart to Lipitor.
Talk to your doctor about your risk and about Lipitor."

- Adding Lipitor may help, when diet and exercise are not enough. Unlike some other cholesterol-lowering medications, Lipitor is FDA-approved to reduce the risk of heart attack and stroke in patients with several common risk factors, including family history, high blood pressure, low good cholesterol, age and smoking.
- Lipitor has been extensively studied with over 16 years of research. And Lipitor is backed by 400 ongoing or completed clinical studies.

*Patient's risk factors include age, gender, smoking, and high blood pressure.

IMPORTANT INFORMATION: LIPITOR is a prescription drug. It is used in patients with multiple risk factors for heart disease such as family history, high blood pressure, age, low HDL ('good' cholesterol) or smoking to reduce the risk of heart attack, stroke and certain kinds of heart surgeries. When diet and exercise alone are not enough, LIPITOR is used along with a low-fat diet and exercise to lower cholesterol.

LIPITOR is not for everyone. It is not for those with liver problems. And it is not for women who are nursing, pregnant or may become pregnant. If you take LIPITOR, tell your doctor if you feel any new muscle pain or weakness. This could be a sign of rare but serious muscle side effects. Tell your doctor about all medications you

take. This may help avoid serious drug interactions. Your doctor should do blood tests to check your liver function before and during treatment and may adjust your dose. The most common side effects are gas, constipation, stomach pain and heartburn. They tend to be mild and often go away.

LIPITOR is one of many cholesterol-lowering treatment options that you and your doctor can consider.

Please see additional important information on next page.



LIPITOR
atorvastatin calcium
tablets



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IMPORTANT FACTS



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LOWERING YOUR HIGH CHOLESTEROL

High cholesterol is more than just a number, it's a risk factor that should not be ignored. If your doctor said you have high cholesterol, you may be at an increased risk for heart attack. But the good news is, you can take steps to lower your cholesterol.

With the help of your doctor and a cholesterol-lowering medicine like LIPITOR, along with diet and exercise, you could be on your way to lowering your cholesterol.

Ready to start eating right and exercising more? Talk to your doctor and visit the American Heart Association at www.americanheart.org.

WHO IS LIPITOR FOR?

Who can take LIPITOR:

- People who cannot lower their cholesterol enough with diet and exercise
- Adults and children over 10

Who should NOT take LIPITOR:

- Women who are pregnant, may be pregnant, or may become pregnant. LIPITOR may harm your unborn baby. If you become pregnant, stop LIPITOR and call your doctor right away.
- Women who are breast-feeding. LIPITOR can pass into your breast milk and may harm your baby.
- People with liver problems
- People allergic to anything in LIPITOR

BEFORE YOU START LIPITOR

Tell your doctor:

- About all medications you take, including prescriptions, over-the-counter medications, vitamins, and herbal supplements
- If you have muscle aches or weakness
- If you drink more than 2 alcoholic drinks a day
- If you have diabetes or kidney problems
- If you have a thyroid problem

ABOUT LIPITOR

LIPITOR is a prescription medicine. Along with diet and exercise, it lowers "bad" cholesterol in your blood. It can also raise "good" cholesterol (HDL-C).

LIPITOR can lower the risk of heart attack or stroke in patients who have risk factors for heart disease such as:

- age, smoking, high blood pressure, low HDL-C, heart disease in the family, *or*
- diabetes with risk factor such as eye problems, kidney problems, smoking, or high blood pressure

POSSIBLE SIDE EFFECTS OF LIPITOR

Serious side effects in a small number of people:

- **Muscle problems** that can lead to kidney problems, including kidney failure. Your chance for muscle problems is higher if you take certain other medicines with LIPITOR.
- **Liver problems.** Your doctor may do blood tests to check your liver before you start LIPITOR and while you are taking it.

Symptoms of muscle or liver problems include:

- Unexplained muscle weakness or pain, especially if you have a fever or feel very tired
 - Nausea, vomiting, or stomach pain
 - Brown or dark-colored urine
 - Feeling more tired than usual
 - Your skin and the whites of your eyes turn yellow
- If you have these symptoms, call your doctor right away.

The most common side effects of LIPITOR are:

- Headache
- Constipation
- Diarrhea, gas
- Upset stomach and stomach pain
- Rash
- Muscle and joint pain

Side effects are usually mild and may go away by themselves. Fewer than 3 people out of 100 stopped taking LIPITOR because of side effects.

HOW TO TAKE LIPITOR

Do:

- Take LIPITOR as prescribed by your doctor.
- Try to eat heart-healthy foods while you take LIPITOR.
- Take LIPITOR at any time of day, with or without food.
- If you miss a dose, take it as soon as you remember. But if it has been more than 12 hours since your missed dose, wait. Take the next dose at your regular time.

Don't:

- Do not change or stop your dose before talking to your doctor.
- Do not start new medicines before talking to your doctor.
- Do not give your LIPITOR to other people. It may harm them even if your problems are the same.
- Do not break the tablet.

NEED MORE INFORMATION?

- Ask your doctor or health care provider.
- Talk to your pharmacist.
- Go to www.lipitor.com or call 1-888-LIPITOR.

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Distributed by Parke-Davis, Division of Pfizer Inc.
New York, NY 10017 USA
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PM TEST
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→ Pontiac Solstice GXP Coupe | Honda DN-01 | Audi R8 5.2 FSI Quattro | Volvo XC60 | Toyota Prius X



P M N E W C A R S

test drives

1 2010 Volvo XC60

2 2010 Toyota Prius

TESTED:
Prius vs. Insight

Gas vs. Diesel

Recently we got a taste of what could be Volvo's future. The automaker tossed us the keys to a pair of XC60s—a U.S.-spec 281-hp 3.0-liter six-cylinder T6, and a 182-hp 2.4-liter five-cylinder turbodiesel European version. To see how a diesel engine could improve the fuel economy of Volvo's latest crossover, we drove them both on a 662-mile marathon. On the freeway, the gas engine was clearly more responsive. But on the slow and steep hilly roads, the diesel's rich torque made climbing easy. Both XC60s provided sure-footed, even sporty handling. So was diesel king? Perhaps. The gas XC60 returned 19.7 mpg; the diesel, a healthy 27.2 mpg. We hope Volvo brings the diesel here soon. — MARK WILLIAMS

Benchmarked

The hybrid by which all others are measured has officially raised the bar. The \$24,000 (est.) third-generation Prius not only saves more fuel than the old one, but it also rolls with Lexus-like refinement. The Prius loses its quirky and synthetic driving dynamics, too. It feels surprisingly sporty—yes, a sporty Prius—and it's remarkably quiet. A larger 1.8-liter four-cylinder replaces the 1.5-liter unit. While this doesn't sound like a recipe for fuel savings, it makes more torque at a lower rpm, so it revs less, and that saves fuel. The EPA fuel economy improves slightly to 51 mpg city and 48 mpg highway, and the new Prius will run to 60 mph in 9.8 seconds, about a half-second quicker. Luxury options include a "Lane Keep Assist" system that nudges the steering wheel to stay on course, automated parking and a precollision system with partial autonomous braking. — L.W.

On our comparison test drive, we found the Prius to have an extra layer of finesse. The engine is quieter—and quicker. The \$19,500 (est.) Honda is cheaper than the Prius and runs a simpler hybrid system that limits electric-only operation. For 295 miles of mixed driving the Insight returned 40.9 mpg; the Prius 45.8. Factor in the larger rear seat and more serene cabin and we'd stretch our budget for a Prius. — L.W.

PM TEST
DRIVEN



2009 INFINITI G37 COUPE

VS.

2010 HYUNDAI GENESIS COUPE



Unlikely Rivals

THE HYUNDAI GENESIS COUPE LOOKS LIKE AN INFINITI KNOCKOFF, BUT DOES ITS PERFORMANCE BACK UP THE SLICK DESIGN? BY LARRY WEBSTER

the SPECS > These two cars are stunningly similar when the technicals are examined. Dimensionally they're close, but the Hyundai, at 3480 pounds, is about 300 pounds lighter than the Infiniti. Under the hood, the Infiniti appears to have the edge. Its V6 cranks out 24 hp more than the Hyundai does. Both cars have paddle-shifted automatics and handling packages. At a mere \$500, the Hyundai's was a deal. The Infiniti's Sport package runs \$1850 and includes much of the same equipment. But the G37 has luxury features not included in the Genesis, like the \$2200 navigation system, full power seats and a power tilt and telescope steering column. The question is, does the Infiniti feel more expensive from behind the wheel?

INFINITI G37 COUPE		VS.	HYUNDAI GENESIS COUPE	
\$45,045	PRICE		\$31,750	
3.7-liter V6 7A	ENGINE / TRANS		3.8-liter V6 6A	
330@7000	HORSEPOWER		306@6300	
5.7	0-60 MPH (SEC)		5.9	
13.9	1/4 MILE (SEC)		14.1	
101	1/4 MILE (MPH)		99	
119.3	60-0 BRAKING		112.4	
23.0	FUEL ECONOMY (MPG)		22.7	

the DRIVE > We ran the pair on 300 miles of sinewy mountain roads near Frazier Park, Calif., and neither car seemed to carry the performance edge. We could confidently dive into a corner in the G37 and the Hyundai would be filling our rearview mirror with that big chrome "H." The same was true when we switched cars—the Infiniti was tail-grabbing the Hyundai. On the surface, these coupes appear to be equals. But we noticed some subtleties. The Infiniti's steering was a tad more fluid, and maybe a tick more direct—call it an overall refinement. On the long ride home from our 300-plus-mile comparison test, the Infiniti proved a touch quieter and offered more comfortable seats.

BOTTOM LINE > So do the Infiniti's extra refinement and features warrant the extra dough? The Hyundai's straight-line performance and handling prowess make the G37's premium a bit steep—the Genesis wins by a nose.



2009 NISSAN CUBE

2009 SCION xB



VS.



2010 KIA SOUL SPORT

Battle of the Boxes

THE ARRIVAL OF NISSAN'S CUBE MEANS THE BOXY-CAR CLASS HAS EXPANDED FROM ONE TO THREE THIS YEAR. HERE'S HOW THE CUBE STACKS UP. **BY BEN STEWART**

In terms of pure funk, none of the other boxes on this page can beat the Cube. The design is very simple, very Japanese and very hip. Underneath the skin is Nissan's Versa chassis, and its 122-hp 1.8-liter four-cylinder too. Our \$16,385 Cube S was equipped with the CVT transmission. Around town it delivered sprightly acceleration and easy maneuverability; the suspension soaks up large potholes with ease. But once the road begins to curve, the Cube proves it isn't the sportiest box around. The steering feels artificial and less indicative of what those front wheels are actually doing. Inside, the Cube is an amazingly fun place to spend time. The

experience is like a social club, with cool details like the "water drop" rippled headliner and pod instrumentation—and the Cube offers a great view from any window. When it comes to utility, we particularly liked the asymmetrical rear door that offers two detents, one at about 9 inches and the other all the way open. Nissan smartly engineered this rear door to open away from the curb, and that makes loading just about anything simple. Likewise, we found comfort in the rear seat, good for three adults thanks largely to the enormous amount of headroom and the flat floor. The Cube may not be the largest or sportiest in the class, but it does offer plenty of practicality, value and fresh, authentically quirky design.

After one very long day testing these three boxes back-to-back over a round-trip route that stretched from Santa Monica to Solvang, Calif., each car's unique personality bubbled to the surface. The Cube, which delivered 30.8 mpg, was the hip city car made for easy urban living. And though the Scion was the powerful long-distance hauler with the most room, it returned only 28.6 mpg. But it was the Kia Soul Sport that emerged as the speedy canyon carver and mileage champ (31.2 mpg) of this group. It was our favorite in this test.



2010 Mercedes-Benz E-Class

The new E-Class is mechanically similar to the current car. So there's a 268-hp V6 and 382-hp V8 as well as all-wheel drive and the hot-blooded E63 AMG version. But Mercedes will debut new tech in the E-Class, like Attention Assist, which detects when the driver is drowsy.

2010 Mazda Mazdaspeed3

The current Mazdaspeed3 is by many measures the sport-compact gold standard. The 2010 model will remain turbocharged and produce around 263 hp. Though some rivals send power to all four wheels, this hot sedan will remain front-drive.

2010 Porsche Panamera GT

The first Porsche four-door sports sedan will arrive later this year with a choice of two 4.8-liter V8s—a 400-hp model and a 500-hp Turbo. Both will use Porsche's amazing new PDK gearbox, and all-wheel drive will be an option. A V6 hybrid model is now in the works. The Panamera will arrive here this fall.

2010 Ford Taurus SHO

The Super High Output (SHO) Taurus returns after a decade-long absence, with all-wheel drive and a new twin-turbo V6 packing 365 hp. An optional Track Pack with 20-inch wheels should add handling poise.

2010 Dodge Ram 2500/3500 HD

Dodge has brought the new Ram 1500's aggressive design to the beefy 2500 and 3500 heavy-duty trucks. But don't think Dodge just lifted the look verbatim. Nope. The bigger trucks get their own hood, grille and bumpers. The standard 5.7-liter Hemi V8 delivers 383 hp and 400 lb-ft of torque. Of course, the 6.7-liter Cummins turbodiesel engine, packing 350 hp and a robust 650 lb-ft of torque at a superlow 1500 rpm, is the engine for the tough jobs. Tow-friendly features include larger

flip-up mirrors with integrated turn signals, memory function and puddle lamps. But the biggest news is that the heavy-duty pickups will finally be available as a true crew-size cab pickup, providing Dodge with an entry into the highest-volume part of the heavy-duty pickup segment.



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*Range of 27% - 88%

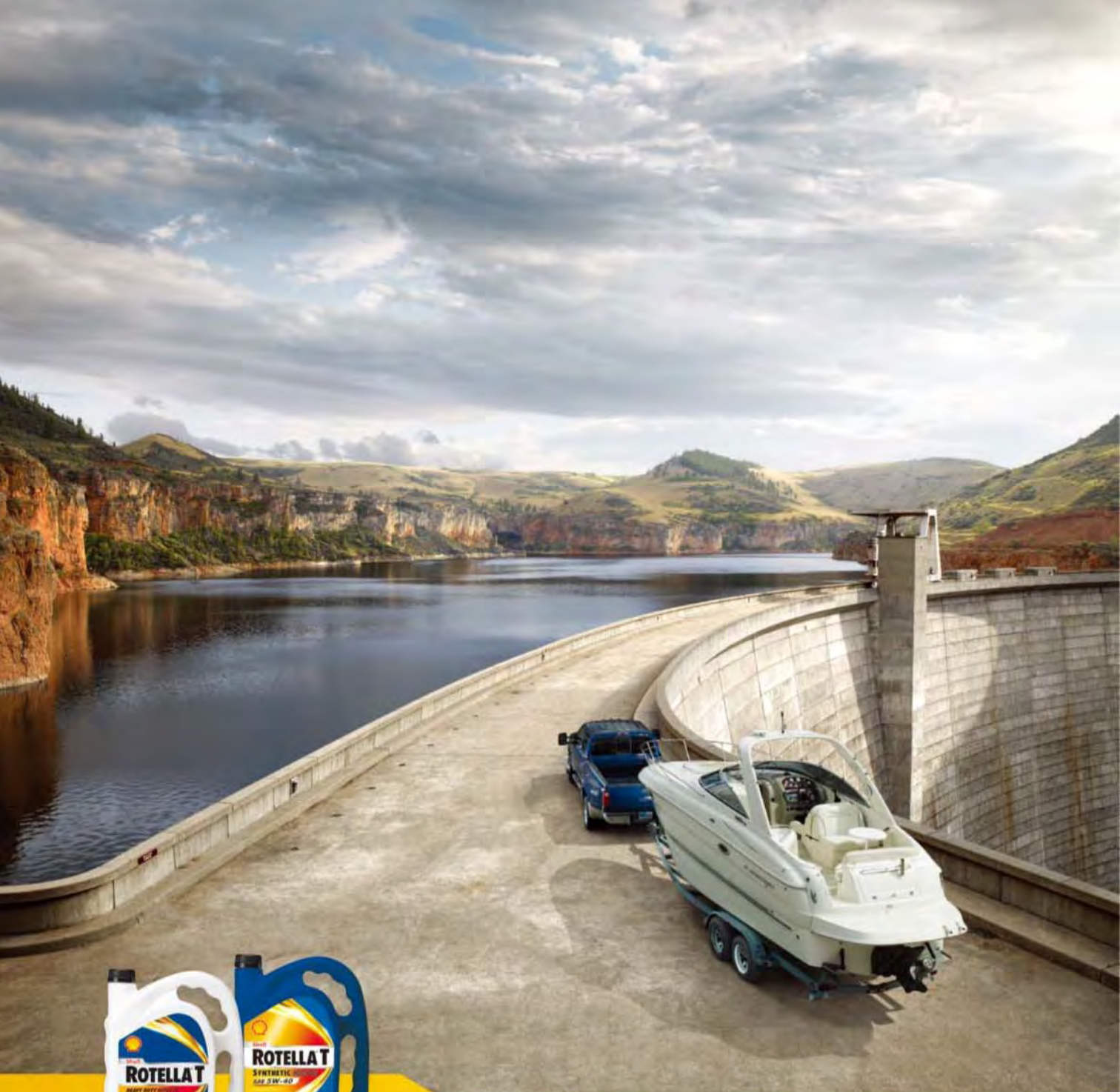


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Long-Term Test Cars

THE DEFT MITSUBISHI EVO DEPARTS AS A DIESEL VW ARRIVES—LET THE HYPERMILING BEGIN.

PM TEST
DRIVEN



VW Jetta TDI **Loyal Edition**



FIRST REPORT

Fuel-efficient transportation doesn't necessarily have to mean boredom behind the wheel. Hybrids may grab the headlines, but we're smitten with clean diesel. This alt fuel has reinvented itself recently, providing an excellent

compromise between fuel economy and performance. And when it comes to maximum diesel fuel economy, the new Jetta TDI is the reigning champ. In a PM comparison test earlier this year, we pitted a Jetta TDI against a

2008 Prius. On our highway fuel-economy run, the TDI actually beat the Prius by a small margin, topping 45 mpg. That sealed it—we just had to add a Campanella White VW Jetta TDI to the PM long-term test fleet. One

■ **VITAL STATISTICS** Base price \$22,440 : As-tested price \$24,190 : Extra-cost options Six-speed DSG gearbox : Drivetrain 2.0-liter turbodiesel I-4, 6/DSG, front-wheel drive : Engine performance 140 hp, 236 lb-ft of torque : EPA fuel economy 29 city/40 hwy

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cool trait of the TDI is that it doesn't look like it's trying to be green. Only a small TDI badge on the trunk gives it away. Our Loyal Edition came with just one option—VW's smart-shifting Direct Shift Gearbox (DSG), a twin-clutch automated manual transmission. As much as we enjoy a good manual transmission, the DSG is far more pleasant than rowing through the gears in city traffic. Our TDI has already been on quite a number of road trips so far—the longest from L.A. to San Francisco. The fuel economy has been all over the map too. When we're trying to maximize efficiency, we've covered over 500 miles on one tank and seen north of 40 mpg. However, around town, when using the diesel's deep torque reserves at every stoplight, we've seen fuel economy dip as low as 25 mpg. But we've got a full year to play the fuel-efficiency game with our Jetta TDI. This could be the perfect candidate for an L.A.-to-NYC mileage marathon. Any takers? —BEN STEWART



Jettas may seem almost ubiquitous on the road. But often it's the details of a car that set it apart. This Jetta has a tiny VW logo in the center of the headlamp. Neat.



Subaru Forester 2.5XT Limited



SECOND REPORT

We've used the Forester mostly for urban commuting and grocery-getting, but it did make one major road trip, racking up more than 2000 miles in four days to visit family back in Michigan. The Subie is a comfortable ride on a long haul, until the wind picks up a little and you realize how sensitive it can be in crosswinds. We used the auxiliary input jacks in the center console to provide entertainment. And it's a good thing we had them, considering there isn't much in the way of decent radio programming burning along I-80 in Pennsylvania and Ohio. Too bad those RCA input jacks are so hard to access. Seriously, the Subie proved to be a stout and reliable road tripper. We used it to haul a fair amount of stuff back and forth too. So we were pleased that the rear seats folded so easily, opening up the rear cargo area for transporting chairs, building materials and a fair amount of photo equipment for a few Saturday Mechanic photo shoots. And whether we were bumbling around in town or eating up miles on the freeway, the fuel economy was enviable. —MIKE ALLEN

DRIVERS NOTEBOOK

• We dig the surprising gusto from the turbo Four. In a Subaru Forester, you can be practical, loading the roof rack full of gear every weekend—and still tap your inner gearhead by burning a little rubber.

• There's really not much legroom in the front seats.
• The FM radio reception is staticky anywhere except near the station.

DATA SO FAR

As tested : \$32,420
Previous reports :

See 02/09

Miles driven : 5843

Miles since last

report : 5602

Fuel economy :

Average—18.2 mpg

Worst—14.5 mpg

Best—22.0 mpg

Maintenance/repair : \$0



Nissan Maxima 3.5 SV



THIRD REPORT

We almost wish there was more to complain about with our Maxima. Ho-hum design, perhaps? Nope. The Maxima looks razor-sharp. Performance? Well, it's designed more for comfort than for hitting apexes, but Nissan's healthy 290-hp V6 will happily get up and go. Well then, how about the interior? Sorry again. The feel inside is just a half step below the Infiniti G35 Sport we had in our fleet last year—the Maxima is a

lovely place to spend a few hours. Reliability? Not a glitch, so far. Then, what about mileage? Okay—here, we have to admit, we've been averaging just under a so-so 22 mpg. But we have coaxed as much as 28 mpg from the Max, so we have only our own right foot to blame. Are we getting bored with all this unobjectionableness?

Not even close. —JIM MEIGS

DRIVERS NOTEBOOK

- Trunk pass-through comes in handy when packing skis.
- The keyless start is a matter of preference. Some drivers don't like searching every pocket and receptacle for the key fob whenever they leave the car.
- Scheduled service at 3500 miles was blissfully uneventful.

DATA SO FAR

As tested : \$37,550
 Previous reports :
 See 11/08, 02/09
 Miles driven : 7012
 Miles since last report : 3633
 Fuel economy :
 Average—21.7 mpg
 Worst—17.4 mpg
 Best—26.1 mpg
 Maintenance/repair : \$46.14



Mitsubishi Lancer Evolution MR



FINAL REPORT

There is a toggle switch behind the shifter that allows you to select between Normal and Sport transmission settings. But if you're feeling particularly feisty—and you've got miles of clear asphalt ahead—hold that toggle switch forward for a few extra seconds. This move will engage S-Sport mode, "Super Sport." What does it do? Well it's sort of like feeding the transmission a beer bong loaded with Red Bull. The shifts become petaflop-quick with a violence that rivals internal combustion itself. The experience leaves you mouthing words we can't print here. And that's just the upshifts. Super Sport will rev-match nearly as high in the rpm band as you need. It's brilliant. Best of all, you can toggle back to Normal at any point and have shifting as smooth as any automatic. It's this Jekyll-and-Hyde gearbox that sums up the whole Evo experience. Here is a sedan with the soul of a supercar—yet daily docility is just a toggle switch away. The Evo has proven to be stone-reliable too. Downsides? Drive it hard and the tires do wear quickly. But that's about it. We're sad to let this one go. —B.S.

DRIVERS NOTEBOOK

- The cloth seat inserts hold you in place for hard driving. Leather seats are for wimps.
- The transmission sometimes "clunks" in hot weather. Mitsubishi says it's normal and happens because the oil is lighter than conventional transmission fluid to dissipate heat.
- The touchscreen sound system is annoying to use at speed. We'd prefer an old-school knob to change radio stations, thank you.

END DATA

As tested : \$41,740
 Previous reports :
 See 08/08, 11/08, 2/09
 Miles driven : 10,162
 Miles since last report : 3543
 Fuel economy :
 Average—18.5 mpg
 Worst—14.4 mpg
 Best—23.0 mpg
 Maintenance/repair since last report : \$0
 Overall : \$105
 (scheduled service)

FUTURE COLLECTIBLES

> BY JAY LENO

> ILLUSTRATIONS BY IAN KELTIE



About 10 years ago, I had the chance to buy a McLaren F1. A new one was almost a million dollars. This was a secondhand car with less than 2500 miles, and it was \$800,000. I thought, it's crazy to spend that much money on a car. So I talked it over with my wife. And she said, "You've worked hard. If you want to get it, get it." And I thought, *ohhh ... kaaaay!* So I bought it.

Last year, a McLaren F1 sold at auction for \$4.1 million! I now realize this is the greatest investment I've ever made. In less than 10 years, I more than quintupled my money. Best of all, I have a car I really enjoy. But there are plenty of modern cars you can buy at real-world prices that are fun to own.

People ask me if they should buy a new car and tuck it away as an investment. I think it's ridiculous to buy something and just squirrel it away. The fuel will eventually go bad, all the moving parts will still have to be lubricated, and you still have to insure it. Cars should be driven. If you let a car sit, you'll eventually have to flush the fuel system, replace the electronics and more. Buying any car and putting it into storage for years gets you

nothing. It's a bad idea. You won't be buying something you like—you're just trying to make money.

There are plenty of guys who bought the original Dodge Viper as an investment. When that car first came out in 1992, it produced 400 hp, an incredible level of power for that time. People thought, "That's it. They'll never make a car more powerful. I'll buy one and stick it in my

IT'S BEEN 10 YEARS SINCE JAY LENO'S GARAGE FIRST APPEARED IN OUR PAGES. BUT THIS MONTH, INSTEAD OF LOOKING BACK, JAY CELEBRATES HIS FIRST DECADE WITH PM BY LOOKING FORWARD—AT WHICH CARS TODAY HAVE THE POTENTIAL TO BE COLLECTIBLE IN THE FUTURE.

stocks and bonds? I don't know much about them. In fact, I don't know anything about stocks and bonds. I've lost money in the stock market; come to think of it, I've lost money in real estate too. But I've never lost money on cars.

The reason is simple: I've always bought cars I really want to own. If you buy a car that you like, and it loses its value, at least you still like it. Besides, even if the car's value does go down a little, it will come back up at some point down the road.

S

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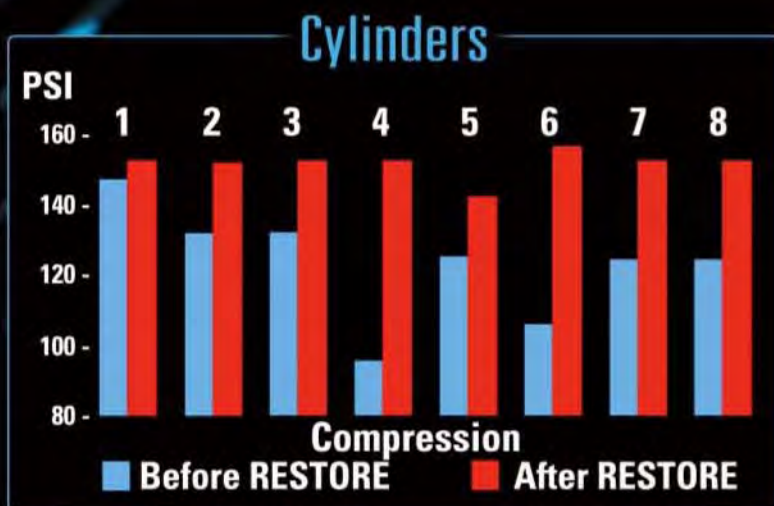
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JAY LENO'S GARAGE///
10TH ANNIVERSARY

garage." Now, every day people call me: "Hey, I've got a '92 Viper with 800 miles." Sorry, I'm not interested. "Three hundred miles?" Nope. You didn't buy it to own it.

But there are some interesting modern cars that are potential collectibles you can drive and enjoy—cars considered common transportation today. I think the first-generation Toyota Prius is a future collectible. Although it was technically innovative at the time, now it just seems cute. It's kind of slow, and it doesn't have tremendous range. But it was the first of its kind—the first mass-produced hybrid—and there's an honest simplicity to that. So if you have an original Prius, in 10 or 15 years, you'll meet people who say, "I bought one of those!" And they'll want to relive the feeling of watching the little dashboard display jump from charging to consuming. That neat feature will bring back a flood of those memories.

It's like when I talk to people who once owned early and mid-1960s push-button Chryslers. They say, "I learned to drive in one of those! You press the D button to go, and you press R for reverse." They remember that feeling of freedom and American progress—simply pressing buttons to drive down the road. So cars with unusual features, technology that cars today no longer have, can be collectible.

Years ago, I was told Mustangs would never be collectibles because Ford built millions of them. We're a disposable society. But eventually, we want what we used to have—the cars we ran into the ground. We've used most of those old Mustangs up, and now they're gone. So

the survivors are highly prized.

Once, when I was visiting England, one of my relatives said, "You like motorcycles—you should talk to our vicar. He has one." So I met the vicar, who owned a '66 Honda 160. I asked how long he'd had it. He looked at me kind of quizzically and said, "I bought it new." He'd had that bike his whole life, and he'd maintained it. To him it wasn't a collectible. Many of us would say, "Oh, I had one of those, and my father threw it away," or "We gave it to a neighbor," or "We rode it to death,"

what it was worth originally just to get it back—often to recapture whatever lost youth we thought we had.

That's why I think the Mazda Miata will be the ultimate affordable collectible by, say, 2025. The first-generation Miata was extremely simple, and that's part of its charm. Years ago, when we were restoring Mustangs, they seemed so complicated compared to a Ford Model A. A brake-light switch? Why do we have to have *thaaaaat*? In a Model A, you just strung together a couple of yards of wire and boom! You were done. So



The first-generation Toyota Prius is a future collectible. It was the first of its kind—the first mass-produced hybrid—and there's an honest simplicity to that.

or "We finally broke it and got something else." In other countries, because motor vehicles aren't seen so much as appliances, they're treated with great respect. This vicar had been riding that Honda 160 for 40 years! It was his only transportation. And it was a survivor.

That's the difference. We want what we used to have. We get rid of it, and then we pay 10 to 15 times over

the early Miata, with no traction control, no stability control—no nothing—will certainly be a collectible.

I think the first-generation Taurus, the forward-looking aerodynamic sedan, will be collectible too. That was seen as a real styling triumph in the mid-1980s. Almost anything built before today's government safety regulations could be collectible. In the future, cars lacking these systems

will appear so odd to people.

Obviously, Corvettes and Ford GTs will always be desirable, because they were collectibles from the day they came out. Back in the '60s, who would have dreamed that a Corvette would have 638 hp and get 20 mpg? That was unheard of!

It's harder to predict the ones you don't necessarily remember off the top of your head—like the first-generation Honda Insight. Only about 18,000 were sold worldwide. But look at them now and you think,

there are any of them left. The Aztek is so odd-looking and weird that people want to collect them, like the popular "nerd cars"—AMC Gremlins and Pacers and Ford Pintos. Remember those VW vans with all the windows, or even mid-1980s Chrysler K-cars with the fake wood? It looked fake then. It still looks fake. But today people want 'em. These models have personalities. They're not jellybean cars.

Another one to watch will be the most recent version of the Cadillac

might have one of those anachronisms, a Cadillac with a stick—that'll seem unbelievable.

Despite all the abject scorn and hatred for the Hummer, it has to go on the collectible list. Hummers are languishing on used-car lots. The brand has become the poster boy for bad environmental behavior. But when we're all driving hydrogen cars, someone will say, "Look at that thing. What the hell is that?" The Hummer will be the '59 Cadillac of 2025. The Hummer went from being very desirable to just being hated. And I think the pendulum will eventually swing back the other way.

You know those Cadillac Escalades, with the big dub wheels and other flashy trim? When today's young men are in their 50s and 60s, they'll say, "I wanna drive one of those again and cruise around like we used to." So, those 'Slades will be collectibles.

On the other hand, buying a modern Ferrari as a collector car is not a good idea. If you buy a '50s to '70s Ferrari, you could do the work yourself. But from the mid-1990s on, no one can do the work on it except Ferrari. For almost any other car, an onboard-diagnostic machine is \$600 to \$1000. For Ferrari, it's something like \$22,500. That's what it costs. Just the handheld! So someone who does his own maintenance is simply not capable of repairing a late-model Ferrari—any profit

you think you'll make just isn't going to happen.

One last collectible? It's any car your girlfriend thinks is cute. A '79 Ford Fiesta? "Oooh, look at that little thing!" It's seen as a cute, desirable city car. The new Smart cars will always be collectible. Minis too. Things don't change. If a woman was cute 20 years ago, she's cute today. The same is true for cars.

PM



Despite all the abject scorn for the Hummer, it has to go on the collectible list. When we're all driving hydrogen cars, someone will say, "Look at that thing. What the hell is that?"

wow, it's a two-seater, it gets up to 70 mpg, it's got an interesting shape and it's very aerodynamic. Any car that was ahead of its time, or any car that had an interesting flaw—that's what collectors want.

Just as the much-maligned Ford Edsel of the late 1950s is collectible today, so too will be the Pontiac Aztek in the future. No kidding—Azteks will be really collectible if

CTS-V with a six-speed standard. In the future, the manual gearbox will almost become a curiosity. People who know how to shift one properly will be seen as skilled individuals who can really drive an old car. In 2025 they'll say, "You can drive a 2009 556-hp Cadillac stick?" By then, everything will be some version of a double-clutch, automatic-synchro, paddle-shifter ... The fact that you



Jamie Hyneman (left) and Adam Savage build a newspaper boat, *Yesterday's News*, and rig it for an Alaskan launch.



FROZEN SKIFF

> BY JAMIE HYNEMAN

> PHOTOGRAPHS BY CHARLIE STARR

A

INVENTOR GEOFFREY PYKE ONCE PROPOSED BUILDING SHIPS OUT OF ICE. MYTHBUSTERS JAMIE HYNEMAN AND ADAM SAVAGE SEE IF IT CAN BE DONE.

lot of mythology surrounds British inventor Geoffrey Pyke. He supposedly made people come to his bedside to see his designs because getting up and getting dressed took too long. It seems fitting somehow that such a quirky character could convince the British War Office in 1942 to test the concept of massive floating platforms made of ice—insulated and cooled “berg ships” up to 4000 feet long to be used as bomb- and torpedoproof aircraft carriers that would protect North Atlantic shipping lanes.

The following year, Pyke's former professor and his assistant discovered that adding wood pulp or sawdust to water before freezing would make far stronger platforms. They named the material pykrete in honor of Pyke. By the time two small-scale prototypes were built, longer-range aircraft were patrolling the Atlantic, and the wild scheme was largely forgotten.

Mythology, strange materials, bombproof stuff—that's all right down our alley, so I proposed taking on the story as an episode of *Myth-Busters*. The problem was, I couldn't convince

our producers to let Adam Savage and me build an aircraft carrier. A smaller boat, however, would present its own challenges: I was pretty sure its thin pykrete hull wouldn't be strong enough for the job. So I started thinking about how to bolster it.

If you break it down, pykrete is really a type of particleboard that uses water as the binding agent instead of glue. But it's weak like particleboard, which has limited structural strength. So what would be a stronger alternative? Plywood! Its layers of wood veneer and glue form a stable, sturdy sandwich. And since pykrete can be made with wood

pulp—well, newsprint is made from pulp. We thought: What if we make a “plywood” boat out of frozen, laminated newspapers? That’s what we pitched to our producers, and that’s what we did. You may have already seen the episode (scheduled to air April 15 on the Discovery Channel). But, as usual, a lot happened that we couldn’t fit on the show.

First, we tested whether our newspaper variation was stronger than pykrete, which is surprisingly tough but brittle. You can break it with just a couple of hammer whacks. It turned out that our version was off the charts for strength. We stacked 400 pounds of lead on one end of a 2-inch-thick newsprint plank clamped to a workbench, and then hammered away. We finally gave up. Basically, it was about as strong as 2-inch-thick plywood. We called the

water to test the boat. Our staff zeroed in on Ketchikan, Alaska, which has ice-free waters in January and a high school with a wood shop where we could work. But the average temperature at that time of year is 38 degrees, so we had to rent a freezer truck. Go to Alaska to rent a freezer... well, it’s not the strangest thing we’ve done on *MythBusters*.

The build was pretty simple. We started the mold by making a platform for the bottom—an enclosed box of 2 x 10s and ¾-inch plywood about 8 feet wide and 20 feet long, just like the floor in a house but with plywood on all sides. It had to be nailed and glued so we could forklift it into the freezer truck. The sides were doubled-up ¾-inch plywood held in place with galvanized brackets. We lined the mold with Visqueen, a light, flexible polyethel-

to remember to lay down the sheets like shingles on a house: One issue at a time, starting at the bow and moving aft, so water flows over the layers, not under them. After about four passes, we had a hull 2 inches thick. Another important thing to remember: Water expands as it freezes, so you need to keep pressure on the newspaper or else it delaminates. We built an inner mold to hold everything in place and hoisted the skiff into the freezer truck.

While the boat was in cold storage, we mounted the 150-hp four-stroke outboard motor that Yamaha loaned us and installed steering, a gas tank, a battery and running lights. Two days later, we drove the truck down to a breakwater and unloaded the mold. The boat slid right off the Visqueen plastic into the water and bobbed around like a normal boat.

Before the skiff melted, we put on Mustang survival suits that the local fishermen wear when something bad happens at sea and headed out as though it was a normal day of angling—except that we were in a paper boat in water just above freezing. I checked to see if Adam was ready and then gunned it, half expecting the 150-hp outboard to rocket forward into us at any minute.

But that didn’t happen. We were soon planing, going about 25 mph.



new material super pykrete.

For the design, I drew on my days as a commercial captain and chose the Carolina skiff, a flat-bottomed boat that’s popular on the Chesapeake and throughout the Southeast. The flat bottom makes a stable work platform for clammers and other watermen; it also means you can plane with relatively little horsepower. Since super pykrete is on the heavy side, we wanted to make sure we had enough power to go fast without resorting to a massive engine.

The project depended on freezing newsprint and keeping it that way. So we needed cold—but not frozen—

ene film that would act as a water seal and mold release.

The newspaper was the hardest part of the build. We recruited an army of high school students to unfold 2000-plus pounds of the *Ketchikan Daily News* and other fine publications and dunk them in tubs of water. Lots and lots of tubs. Newspaper floats before it’s wet, so the kids had to keep pushing it down.

If you ever decide to build a boat out of wet newspaper, it’s important

I CHECKED TO SEE IF ADAM WAS READY, THEN GUNNED IT, HALF EXPECTING THE 150-HP OUTBOARD TO ROCKET FORWARD INTO US AT ANY MINUTE.

Some leaks sprang here and there, but a few sprays from carbon-dioxide fire extinguishers sealed them pretty well, at least for a little while. Whizzing along on a plane with CO₂ fog rolling out the stern—precious.

If I were reading this article I’d be wondering, why go to all that trouble to make something that will last an hour at most? Here’s the thing: It’s like climbing a mountain. For Adam and me, these are adventures. And anyway, who else gets to do this? **PM**



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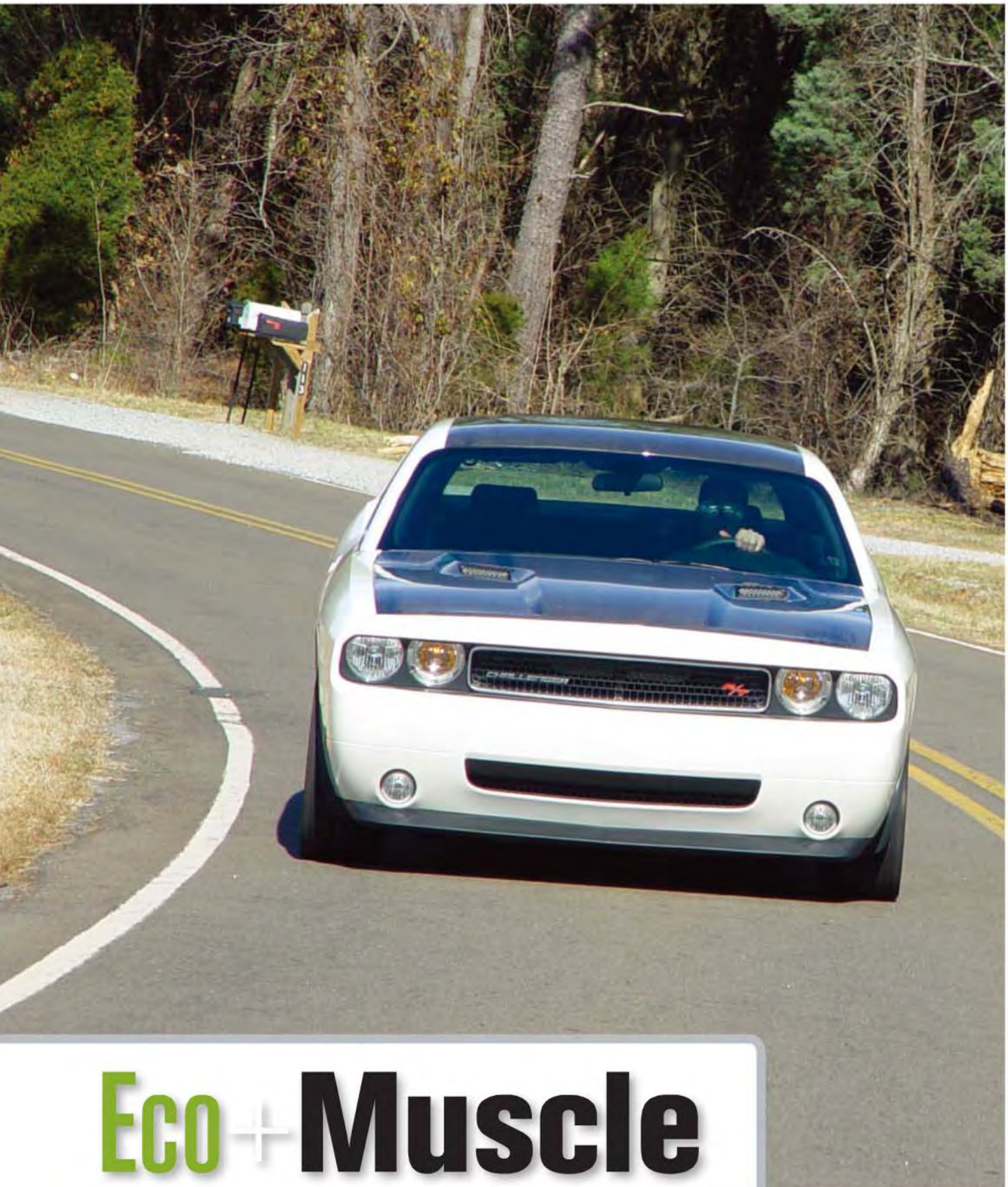
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But what if we use two parallel powertrains, gas and electric, either of which is powerful enough to drive a full-size car? That way, we can offer the muscular V8 performance that buyers crave, yet still produce zero emissions around town.

DODGE CHALLENGER R/T

To prove our point, we've chosen to start with a 2009 Dodge Challenger R/T. Why a Challenger? Well, it's an inexpensive full-size, rear-drive V8 muscle car, something Detroit car companies know how to build better than anybody in the world. It's also beautifully reminiscent of the classic 1970 Challenger, clean and enticing to a wide cross-section of American drivers.

This month, we're improving the already impressive performance of our Challenger, using a variety of inexpensive parts and some clever ideas we've learned at the racetrack. Our goal is a world-class muscle car that out-runs, out-stops and out-corners superexotics that cost ten times as much. That's the "Muscle" half of our project.

Next month, we'll add the "Eco." With inexpensive aerodynamic aids, a state-of-the-art electric drive system and some other helpful bits, we'll turn our potent Challenger into a parallel hybrid plug-in/solar/electric that burns no fuel at all in everyday driving. We

think this is a spectacular way to please both environmentalists and enthusiasts. Eco+Muscle. What's not to like?

You'll be able to examine the Eco+Muscle Challenger in our display at the NASCAR Pocono 500 race in June, at the San Bernardino Route 66 Rendezvous in September and at the Las Vegas SEMA Show in November. Next January, we'll auction it off in Scottsdale. Here's your chance to own one of the most innovative vehicles ever built. Eco+Muscle!

OFF THE DEALER'S LOT

Built on the same chassis as the Dodge Charger/Chrysler 300 full-size, four-door sedans, the Challenger coupe is big and bulky for a muscle car. It also weighs over 2 tons, which affects every aspect of efficiency and performance.

On the other hand, even a base Challenger R/T features all-independent suspension, electronic stability program, traction control, power everything and Chrysler's high-tech MDS VCT engine control unit. The MDS VCT seamlessly deactivates half the cylinders of the V8 during highway cruising, reducing fuel consumption. Therefore, the trick is to improve the Challenger without losing all the things that are already so good about it.

OFF THE LOT **2009 Dodge Challenger R/T**

MSRP:
\$29,820.00

Price as Tested:
**\$30,740.00 (includes
\$725.00 destination charge)**

Layout:
Front-engine/rear-drive two-door coupe

Length:
197.8-in.

Wheelbase:
116.0-in.

Weight:
4041 lbs.

Engine:
90-degree V8, OHV, 2 valves per cylinder, aluminum block and heads

Displacement:
5.7-liters

Compression Ratio:
10.5:1

Power (hp, SAE net):
370 @ 5800 rpm

Torque (lb-ft):
398 @ 4200 rpm

Redline:
5800 rpm

Transmission:
Five-speed automatic

Final drive ratio:
3.06:1

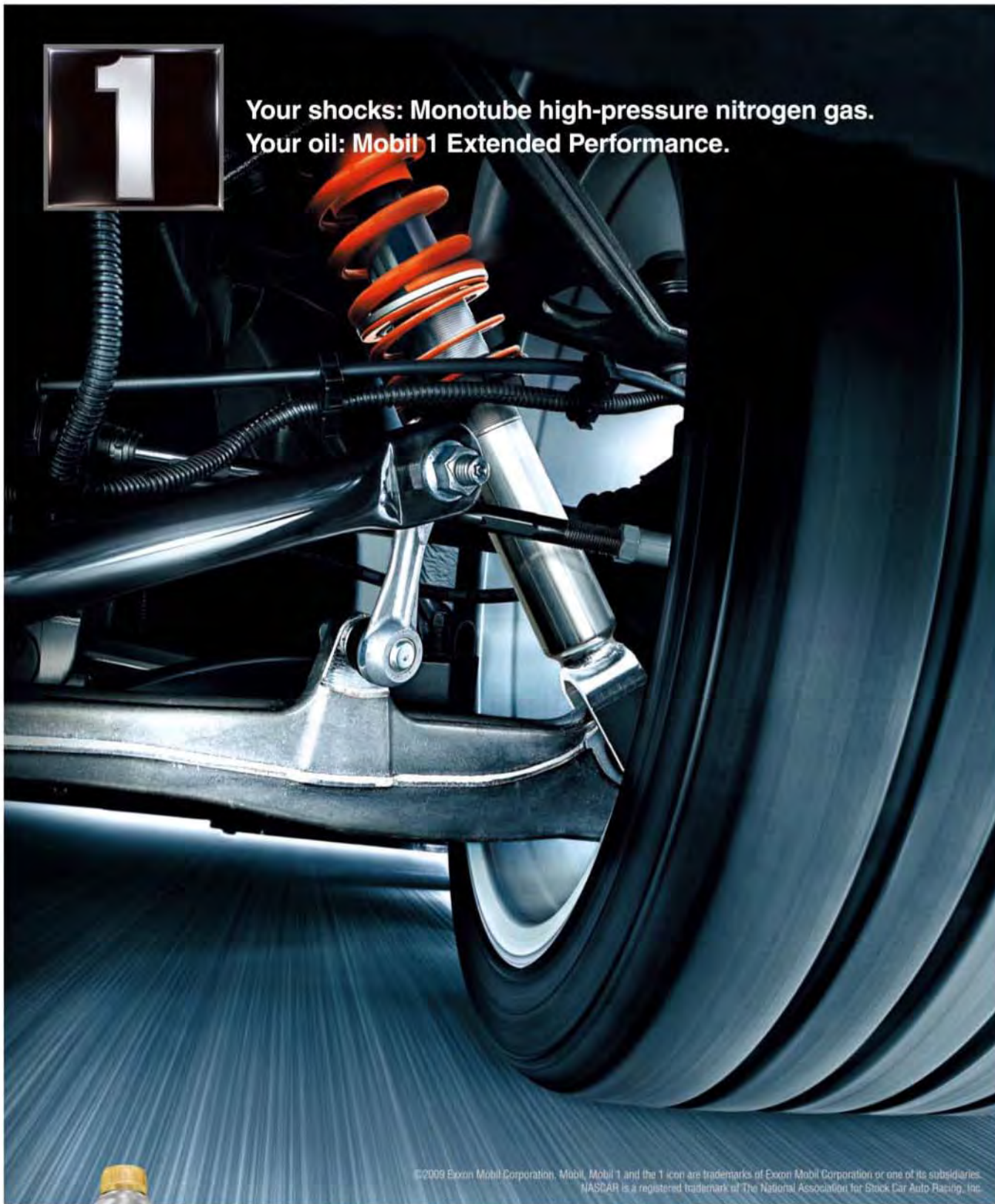
Brakes (f/r):
13.6-in. vented disc/12.6-in. vented disc, ABS

Wheels/Tires:
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P235/55R-18V**

EPA Fuel Economy (city/highway/combined):
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**60-0
111 FT**
**ROAD COURSE
63 SEC**
**FUEL CONSUMPTION
9.0 MPG, CITY**
25.4 MPG, HIGHWAY

We bought a new Challenger R/T with no options at all. Stone White with Dark Slate interior, with 5.7-liter Hemi V8 and five-speed automatic, it cost \$30,740.00.

Straight off the dealer's lot, our new Challenger averaged a miserable 9.0 mpg in stop-and-go traffic.

Thanks to clever computerized cylinder deactivation, however, this big V8 returned a remarkable 25.4 mpg on the highway.

AT THE TRACK

Before we started modifying our Challenger, we needed to obtain baseline performance figures. At Virginia Motorsports Park, we romped from 0 to 60 mph in 4.95 seconds and through the quarter-mile in 13.55 sec @ 103.65 mph. This is strong acceleration for a 2-ton behemoth on OEM street tires! The Challenger also stopped from 60 to 0 mph in an ultra-short 111 feet.

If the stock Hemi V8 and four-wheel

disc brakes are brilliant, the stock suspension is less than stellar. Our showroom-fresh Challenger averaged a mediocre 58.13 mph through a 700-foot slalom with cones spaced 100 feet apart and .83 G around the 200-foot skidpad at Virginia International Raceway.

On VIR's tight Patriot Course, a demanding test of acceleration, braking and cornering, the stock Challenger was not fun. The body swayed a bit on its too-soft suspension, the steering was numb and the street brake pads faded completely after only three laps.

The best we could do was a lap in 63 seconds. To put it in perspective, that's 5 seconds a lap slower than a stock Mustang GT with the same driver. In a race at VIR, the Mustang would lap the Challenger after just 13 laps!

MUSCLE

By the time we got home from VIR, we had a long list of changes to make. The Challenger needed to be lighter and more aerodynamic, with increased power, better brakes and better handling. At the same time, we wanted to keep it street-legal, comfortable, fun to drive and reliable for the everyday commute.

HAYNES

Before we even started to work, we obtained copies of various Haynes manuals including suspension/steering, engine tuning and OBD-II diagnostic tester. We were planning to make changes to almost every area of our Challenger, and frankly, especially when it came to reprogramming the ECU computer, we needed all the help we could get!


HAYNES

Haynes has sold over 150 million manuals since the company started in 1960. Haynes currently offers 500 unique automotive tear-down manuals in the United States, plus over 200 motorcycle and ATV manuals.

To create a Haynes manual, a new vehicle is completely disassembled and then rebuilt. Every step is photographed. More importantly, the disassembly and reassembly is done, hands-on, by the author of the book.

A new Haynes series covers specific areas applicable to any car. Engine performance, suspension and steering, body repair and HVAC systems are things that any home mechanic needs to know. There's even a great new manual on OBD-II testers.

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Q: Which is the best fuel system treatment to maximize your fuel economy?

Use a sharpened No. 2 pencil. Time limit 60 sec. Answer below.

☐ a.

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- Cleans 6 of 6 fuel system parts
- Remains effective for 10 fill-ups



☐ b.

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Correct Answer: a. Gumout Regane.
If you answered correctly, you are an MPG Genius.
Go to gumout.com for more information on how to maximize your fuel economy.



ENGINE

Even in 1902, racers knew that the way to get more power from an internal combustion engine is to allow more air/fuel mixture in and put more exhaust out. A simple C&L Air Induction System with a high-flow air filter replaced the bulky stock air filter housing, greatly increasing the amount of airflow to our Hemi V8.

But it's not enough to get more mixture to the cylinders, you need to get the spent exhaust gases out more quickly, too. We replaced the stock exhaust manifolds with beautiful headers from American Racing, feeding into 2.75-in. exhaust pipes containing small but efficient catalytic converters. A Corsa Performance "cat-back" exhaust with high-flow mufflers and resonators now replaces the heavy, and performance-compromised stock exhaust.

NITROUS

For even more power, we installed a ZEX nitrous oxide injection system feeding from a small nitrous bottle in the trunk into the stock intake manifold through an oversize Signature Series 90-mm throttle body made by Arrington Engines. This billet aluminum plenum flows an additional 178 cubic feet per minute. Indeed, it flows so much more air than the stock throttle body that we had to reprogram the ECU using a Diablo Predator in order to increase fuel flow, too,

The concept of nitrous injection is simple. Nitrous gas provides extra oxygen atoms with every molecule. Forced into the combustion chamber, the extra oxygen combines with additional gasoline to make significantly

more power. Depending on nozzle size, the setup in our Challenger can instantly add up to 175 hp over stock!

Hemi experts told us, however, that the molded plastic intake manifold of the 5.7-liter V8 is a

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potential weak point. We were unable to find an aluminum replacement in the aftermarket. So we've set up our system with a No. 40 nitrous nozzle and a No. 21 fuel nozzle. This combination adds a 75 hp burst at full throttle.

The combination of cold-air intake, headers and exhaust adds about 60 hp to the 370 hp of our stock Hemi. Add a 75 hp nitrous shot, and our Challenger now has about 505 hp to zip 2 tons down the track. That calculates to 7.9



pounds per horsepower! For the sake of comparison, a new Jaguar XK carries about 12.2 lb/hp, a Maserati GT 10.85 lb/hp and a Ferrari 612 8.0 lb/hp.

FUEL-SYSTEM CLEANER

We're making severe demands on our Challenger's fuel system, what with nitrous injection and increased fuel flow. So to maintain optimum performance, we're using Gumout Regane Fuel System Cleaner to clean valves, injectors and combustion chambers. Gumout Regane maximizes both performance and fuel economy.

SPARK PLUGS

Chrysler's new Hemi V8 requires two spark plugs per cylinder for a complete fuel burn. To reliably eke out the most horsepower, we used sixteen Pulstar efi Pulse Plugs. Pulstar Pulse Plugs are claimed to be 10 times more powerful than conventional spark plugs, shooting a violent pulse of electrical spark into the combustion chamber. You can feel the difference.

FILTERS

Over the years, we have used various Wix products including air, fuel, and oil filters in our makeover projects. As always, we are confident in their performance.

A DAY WORKING ON THE CAR WITH MY DAD.

Instead of school I did work on a 2002 Suburban. The hub assembly blew out. We used Haynes Repair Manual to help fix it. My dad did most of the work and I did all of the reading. There was 11 different steps. We had to replace the speed sensor, hub assembly, greased all the spines and put it all back together. Haynes Repair Manual was a really big help to my dad and so was I. The funnest part was test driving it because I knew we did a good job.

Bailey B.



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This year, we installed an inline Wix fuel filter to keep contaminants from clogging our fuel injectors. Wix #57899 oil filter removes even microscopic contaminants from the oil in our Challenger and holds them in the filter element. Our Wix filter exceeds Dodge's specifications, and because of its unique design doesn't restrict oil flow that might rob horsepower.



PULSTAR

Enerpulse, Inc. produces the patented Pulstar Pulse Plug. It looks and installs like a conventional spark plug, but contains an integrated capacitor pulse circuit that delivers ten times more peak power than a conventional spark plug.

Because of the pulsed power technology of the capacitor, the spark flame grows more quickly than from a conventional plug, igniting the fuel mixture in just 2 nanoseconds. The result is better throttle response, better fuel economy, more torque and increased power.

At \$24.95 each, Pulstar Pulse Plugs more than pay for themselves over a typical 50,000 mile service life.

LEARN MORE AT PULSTAR.COM

LUBRICANTS

Synthetic motor oil—like Mobil 1—is literally slipperier than natural mineral oils because the oil molecules are more uniform in size and therefore slide over one another more easily. Typically, Mobil 1 increases power output, reduces fuel consumption and lasts longer between oil changes. Indeed, Mobil 1 Extended Performance needs to be changed only after 15,000 miles.

We poured Mobil 1 Extended Performance 5W-20 into our Challenger's engine. In our 500+ hp V8, we plan to

change the oil and filter every 3000 miles, even with Mobil 1 in the crankcase. We know we're being overly cautious, but an oil and filter change is cheap insurance compared to the cost of a new Hemi.

DIFFERENTIAL

To improve our Challenger's performance, we removed the stock differential and shipped it to our friends at Richmond Gear. Richmond engineers replaced the stock 3.06:1 ring and pinion with 3.55:1 gears and we added a Quaife limited-slip differential to distribute power evenly to both rear wheels for maximum traction.

What we didn't expect was that changing the rear axle ratio confused our Challenger's ECU. The computer promptly energized the Check Engine light and locked the transmission into second-gear "limp home mode."

After consulting everyone, from engineers at Chrysler to local racers, we discovered that Diablo had already anticipated this problem. Using our Predator, we reprogrammed the ECU with different tire sizes, altered the differential ratio and hardened the shift points.

SUSPENSION

The Challenger suspension is actually derived from the Mercedes-Benz E-class, engineered when Daimler controlled Chrysler. It features upper and lower A-arms in the independent front suspension and five separate suspension arms in the independent rear suspension.





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No matter where the vehicle is engineered, made or born, WIX® more than likely has an oil, air, fuel or cabin filter for it. And not just any filter, one that continues to break typical aftermarket stereotypes for fit, form and function. In this great big world of foreign nameplate products, WIX means quality in any language.



See the WIX distributor nearest you or visit wixfilters.com.



WIX. WHERE IT COUNTS.®



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Over the decades Mercedes engineers have had a mantra “soft springs, hard dampers.” In Mercedes cars, this combines to give a smooth ride, but flat cornering. The Challenger somehow ended up with both soft springs and soft dampers. The handling is fine for normal street driving, but too flabby to handle 500 hp.

BILSTEIN

The Bilstein Company, now part of ThyssenKrupp, dates back to 1873. In 1954, Bilstein revolutionized the car industry when it invented and patented the first monotube gas pressure shock absorber.

Today, Bilstein Gas Pressure Shock Absorbers provide precise handling, stability, control and comfort. The rising rate design reacts more quickly to road conditions, while high-pressure nitrogen gas helps keep the tires glued to the road.

Bilstein Gas Pressure Struts use a twin tube design, with the rod pointing down for greater strength and resistance to twisting and side loads. Bilstein shocks and struts typically last four times longer than original equipment.

LEARN MORE AT BILSTEIN.COM



We started by removing the entire suspension, front and rear. We installed a tubular-steel front-shock tower brace from Razors Edge Performance in order to provide a more stable platform for the front suspension.

We then installed a complete suspension upgrade from Pedders USA. The Pedders kit includes racing-style bushings, stiff springs and fat antisway bars for both the front and rear.

We added Bilstein Ultimate Performance shock absorbers front and rear. We've used Bilstein gas pressure shock absorbers in a wide variety of racing and performance cars over the years, and

never had a problem. Bilsteins work!

The Pedders/Bilstein combination lowers the car and dramatically improves handling and traction. Under hard acceleration, there's still quite a bit of axle tramp, but otherwise our Challenger is now extremely well mannered, even when pushed to extremes.

Stock settings for the Challenger front suspension are 9.4 degree left caster/10.4 degree right caster; 0.1 degree left camber/—0.25 degree right camber and 0.1 degree toe-in. Rear suspension settings are —0.5 degree negative camber and 0.17 degree toe-in. To us, this indicates that DaimlerChrysler engineers were trying to compensate for the Challenger's weight-distribution and suspension deficiencies.

We set up our new Pedders suspension “square” as racers say, identical on both right and left sides. At the front we dialed in 9.5 degree caster, —1 degree negative camber and 0.1 degree toe-in. At the rear, we have —0.5 degree negative camber and 0.1 degree toe-in. To be honest, we would have dialed in about 11 degree of caster and —2 degree negative camber if the Pedders suspension offered more range. Adjustable camber/caster plates for the top of the front shock towers would be a useful improvement.





Spending the day with
the family at the lake.



Spending the day waiting for
a jump from the tow truck.



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BRAKES

To improve braking, we acquired a set of exotic Brembo Gran Turismo brakes. These beautifully crafted Italian designs feature six-piston calipers and huge 15-in. rotors for the front plus four-piston calipers and 13.6-in. rotors for the rear. These brakes are so big that stock Challenger 18-in. wheels no longer fit!

To ensure the best possible performance during track testing, we flushed the entire brake system and refilled it with AP Racing 551 brake fluid, the industry standard for racing cars around the world.

TIRES

For high-performance tires, we turned

to Michelin. On the front, our Challenger now wears Michelin Pilot Sport PS2 tires, size 265/30ZR-20 with matching 305/35ZR-20 PS2s on the rear.

In the case of our Challenger, we're after road racing levels of dry traction under acceleration, braking and cornering, as well as superior traction on wet roads. Michelin Pilot Sport PS2s offer incredible levels of wet and dry traction, good tread life, a surprisingly soft ride and low noise.

These very low aspect ratio, ultra-wide tires have a sharp edge between the tread and sidewall. It's imperative that the suspension keep the tread flat to the pavement for maximum traction. Happily, after extensive track testing, we can report that the Pedders/Bilstein combination does a masterful job. The total system works beautifully to transform both the feel and performance of our Challenger. It's the best aftermarket suspension package we've ever tried.

WHEELS

We found our wheels at Tire Rack. Avarus AV5 chrome five-spoke wheels, size 20x8.5 on the front and 20x10 on the rear, both dress up the car and let the colorful and impressive suspension and brakes be seen in all their glory.

Wheels are obviously a performance upgrade, but also the single most noticeable cosmetic change you can make to any car. We've seen Challengers at the SEMA Show with 22x12 or even 24x14 wheels, but these extreme wheels require fender flares, foul the suspension arms and actually degrade handling and braking.

NOW, MORE MPG WITH THE WORLD'S FIRST ECO-FRIENDLY SPARK PLUG



Actually, it's called a pulse plug—here's why its technology should be in your engine.

Until now, every gallon of gas you bought was ignited by a simple spark plug—an outmoded technology that has barely changed in 100 years. But now you can change to a new eco-friendly pulse plug that uses an advanced technology to make every drop of gas burn better and cleaner.

This new technology—with its eight patents—is based on plasma research supported by the world famous Sandia National Laboratories—and yes, that's definitely rocket science.



See the difference in technology: compare the cross section of a typical spark plug above, with that of the new pulse plug below.



Here's how it works: electrical energy from the engine's power coil is stored in the pulse plug's built-in capacitor. At the exact moment needed, that energy is released in an amazingly quick (two nanosecond), powerful, high-energy pulse.

The result: the improved combustion efficiency burns fuel sooner and more effectively, which means better fuel mileage, less CO₂ based emissions, and better overall drivability. For example, here is the result of a recent, highly-controlled fuel consumption lab test:

2007 Toyota Prius

SPARK PLUG: 44.8 MPG

PULSE PLUG: 49.2 MPG



Test results:

- 4.4 more MPG
- Reduces CO₂ by a quarter-ton annually

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Our new Avarus AV5 wheels are just the right size and much flashier than the pretty but plain five-spoke alloys that came on our Challenger. Along with the extremely low-profile Michelin tires and shiny Brembo brakes, we think they “make” the car.



WIX

Six decades ago, Wix invented the spin-on oil filter. Today, Wix makes high-tech oil filters designed to fit every motor vehicle. The Wix secret is a super-fine filtering medium that cleans oil of all contaminant particles larger than 25 microns, plus an unusually high percentage of smaller particles.

For high-performance engines—including 900 hp NASCAR V8s—Wix makes special heavy-duty filters with nitrile base gasket, metal end caps and high-strength steel center tube. Wix Racing filters withstand a burst pressure of 500 psi and restrict oil flow by less than 2 psi at 4 gpm, providing consistent performance under all conditions.

LEARN MORE AT WIXFILTERS.COM

BODYWORK

The first thing you'll notice is that we've replaced the hood and deck lid with lightweight carbon-fiber parts from Seibon Carbon, plus redone the Challenger roof in carbon fiber to match. Seibon Carbon's parts are beautifully made, easy to install and fit perfectly. Plus, we think carbon fiber gives a futuristic, high-tech look that's very cool.

If you look closely, you may also notice that we've removed the Dodge hood emblem and the outside rearview mirrors to improve aerodynamics. These are details that will

become important next month, when we get into a more extensive reworking of our Challenger's buff bodywork.

CHALLENGER TRANSFORMED

Our hot-rodded Challenger is a blast to drive! It's quick, it's fast, it corners on rails, the gigantic Brembo brakes will lift you right out of your seat, held only by the seatbelts. It's smooth and stable even at extreme speeds and feels as safe no matter how crazy you get. It's a quantum leap better than the stock Challenger with which we started.

One aspect of performance definitely bears repeating. Thanks to the cylinder deactivation program, this 4000 pound machine combines 0 to 60 in less than 4 seconds and the quarter-mile in the low-12s with 25 mpg on the highway. Impressive.

Our Challenger can be tossed around like a lightweight Porsche or Ferrari. But is it an exotic sports car? No.



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TRACK TEST RESULTS

0-60 MPH

Stock: 4.95 sec

Modified: 4.50 sec

Improvement: .45 sec

Nitrous Injection: 3.95 sec

Improvement: 1.00 sec

QUARTER-MILE

Stock: 13.55 sec @ 103.65 mph

Modified: 12.9 sec @
110.50 mph

Improvement: .65 sec and
6.85 mph

Nitrous Injection: 12.4 sec
@ 114.0 mph

Improvement: 1.15 sec
and 10.35 mph

SLALOM

Stock: 58 mph

Modified: 63 mph

Improvement: 5 mph

BRAKING

60-0 MPH

Stock: 111 ft

Modified: 95 ft

Improvement: 16 ft

ROAD COURSE

Stock: 63 sec

Modified: 60 sec

Improvement: 3 sec

SKID PAD

Stock: .83 G

Modified: 1.2 G

Improvement: .37 G

FUEL CONSUMPTION

Stock: 9.0 mpg, city/25.4 mpg,
highway

Modified: 8.8 mpg city/24.6
mpg highway

Difference: -.2 mpg city/-.8
mpg highway

PERFORMANCE MODIFICATIONS

American Racing Headers

Avarus AV5 Wheels

Bilstein Ultimate
Performance Shocks

Brembo GT Brakes

C&L Air Induction System

Corsa Catback Exhaust System

Exide Battery

Gumout Regane Fuel System
Cleaner

Michelin Pilot Sport PS2 Tires

Mobil 1 Extended Performance
5w-20

Pedders Suspension

Pulstar Pulse Plugs

Quaife Limited-Slip Differential

Razors Edge Shock Tower Brace

Richmond 3.55:1 Differential

Seibon Carbon (Hood/Trunk)

Wix Filters (Fuel/Oil)

Zex Nitrous System

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It's a really neat American muscle car, what we all wished our Mustangs and Camaros and Challengers could have been back in 1970.

On its lowered suspension, with the fattest tires we could fit under the fenders and carbon fiber everywhere, this Challenger looks mean and lean, with the brutal stance of a classic Trans Am racer.

COMING IN JUNE

Now that we've successfully completed the "Muscle" part of this car, we're ready to add the "Eco." In the June issue, we'll make our

classic Challenger body even more aerodynamic, plus add a hybrid electric drive train powered by two dozen Exide batteries. Evolve-It Motors is giving us high-tech advice. Then we'll see if we can't cruise around New York City using no fuel at all.

We'll repaint the body in a classic Challenger paint scheme using Dupli-Color paints, redo the interior with new Corbeau bucket seats, Dupli-Color trim and an incredible Kicker Sound System designed specifically for the Challenger with new speakers, twin woofers and auxiliary amplifiers. We'll clean, polish and protect the whole car inside and out using Meguiar's products, and add some more interior features we've sourced at Rockauto.com.

ECO+MUSCLE

Nobody has ever tried to build a car like this, combining racetrack performance with partial zero emissions. At this point, to be quite honest, we're not sure we can pull it off, either. We've got the Muscle part down. Now all we have to do is add the Eco part. Check back in the June issue to see if we succeed. And wish us luck! ♦



✓Yes



✓Yes



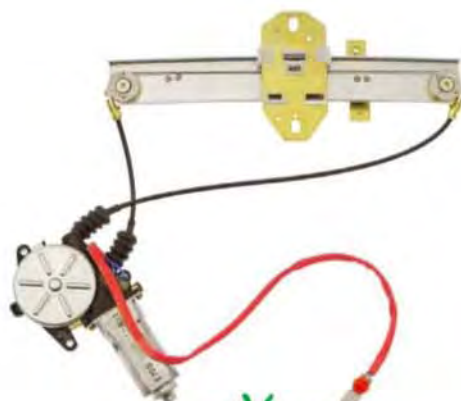
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xNo



✓Yes



✓Yes



✓Yes



✓Yes



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TOOLS

WE CAN'T
LIVE WITHOUT

If PM could design the perfect toolkit, these are the DIY essentials we'd put in it. Now, all we need is a really big box.

Man is "weak in himself, and of small stature," wrote 19th-century essayist Thomas Carlyle. Yet, with tools, "the granite mountain melts into light dust before him, seas are his smooth highway, winds and fire his unwearying steeds." And this from a guy who never felt a 5800-rpm circular saw scream to life in his hand.

While much has changed since Carlyle's day, one thing hasn't: We need tools to build, repair and maintain the mechanical world in which we live. With these 50 tools, you'll be ready for just about any project—whether it's melting mountains or swapping out the kitchen sink.

By Logan Ward

Photograph by Charles Masters

Portraits by Sarah Shatz

1. Sledgehammer

● Few tools combine brute force and finesse as elegantly as a sledgehammer. Swing it overhead to deliver bomb-blast destructiveness or to fire a wood-splitting wedge through a big log. Handle it like a putter to salvage architectural elements such as a post-and-beam barn frame that needs knocking apart. Most of us are better off with an 8- or 10-pound model that we can swing easily, not a 16- to 20-pounder.

2. Center Punch

● In theory, you use a center punch to start holes in metal. In practice, it's far more useful than that. You can tighten a loose handle on a knife or shovel by centering the punch on the rivet and then firmly striking it with a ball-peen hammer, expanding the rivet's head. In a pinch, you can also use a center punch like a steel pencil to mark a line on wood or metal. Or you can use it to countersink a large nailhead or drive down the stub of a broken nail or staple.

3. Putty Knife

● The putty knife is more than a single implement. Rather, it's a group of tools, ranging from knives with flexible, thin blades to heavy-duty models that are ground with a tip like a chisel (which, not surprisingly, are called chisel-edge putty knives). Better tools have a high-carbon steel blade; plastic, disposable ones are perfect for the no-scuff application of putty on painted surfaces.





4. Safety Glasses

● DIY projects may come and go, but you won't get a second shot at good vision—protecting your eyes should be your first priority. Opt for high-impact safety glasses over those rated "basic impact." For maximum protection, wear high-impact goggles because they cover more of your face and the area around your eyes.

5. Adjustable Wrench

● For portability and convenience, you can't beat the time-honored adjustable wrench, which enables you to turn a wide range of nuts and bolts with a single tool. If you're going to own just one, make it a 10- or 14-inch model so that it's big enough for residential plumbing fittings. Pull it so the reaction force is applied to the fixed jaw, not the movable one.

6. Pipe Wrench

● A pipe wrench may not be versatile, but when you need to hold a pipe and fittings, nothing else will work. The body is rigid and heavy, and

the teeth bite forcefully into smooth, round surfaces. While most pipe wrenches are cast iron, spring for an aluminum model if you face a long day of plumbing.

7. Socket Wrench Set

● Reach for a socket wrench when you need to tighten fasteners or loosen frozen ones. The ½-inch drive is the heavy hitter of the socket wrench kingdom, followed by a switch hitter, the ¾-inch drive, which is big enough to do light-duty automotive work yet small enough for some appliances. Reserve the ¼-inch drive for appliance and electronics repair.



9. Combination Square

● Used for marking out, measuring and testing the squareness of corners, the combination square is versatile and accurate. For maximum precision, first position your pencil (or the scratch awl stored in the head), then gently slide the square to the pencil (or awl) and strike your line. Check the tool's accuracy by marking a line 90 degrees to a straightedge. Flip the square and make another mark next to the first. If the two lines are parallel, the square is, well, square.

AIRCRAFT RESTORER

Will Lee

MUST-HAVE TOOL: metal file (8)

If the deadly twin-engine Heinkel 219 had been available in larger numbers, some World War II historians speculate, Germany might have stopped the Royal Air Force bombing that hastened the end of the war. As it was, fewer than 300 of the gun-bristling night fighters were made. Today, one remains, and the Smithsonian National Air and Space Museum's Will Lee is slowly piecing it back together. Along with a rawhide mallet for hammering aluminum, the aircraft restorer's go-to tool is a metal file. He relies on four dozen files to finesse excess metal—both single- and double-cut, triangular and those he's cut down to shave rivets. "With a file, I can get right down to the lines I've scribed," says Lee, who did electrical work and built prosthetic limbs before joining the Smithsonian in 1990. He prefers hand tools for the most precise fits. "I seem to have more control doing it the way I've been doing it for years," he says.

Classics

10. Combination Wrench

Your wife has the family silver tucked away in a felt-lined box, and you've got your set of combination wrenches. The tool's design is prototypically simple—box-end on one side, open on the other. It has no moving parts and is covered in shiny chrome. If you're lucky enough to have inherited the set from your dad, that makes it as precious as the silver, while cheaper to insure. No one knows who invented the combination wrench or when, but it was popularized in the U.S. by Plomb Tools in the 1930s, a period of social and technological ferment. As automobiles became more numerous and sophisticated, so did the tools to work on them. New steel alloys and forging

methods have only improved the wrench with the passage of time. Today's wrench is thinner, sleeker and stronger than the bulky ones it replaced; it weighs half what it did in the '20s. While it is hard to improve on perfection, in 2006 Craftsman introduced a new twist—literally—in its Cross-Force Combination Wrenches, turning the handle so your palm presses on the tool's broad face, not the narrow edge. Back when blacksmiths forged tools, they would inscribe the year onto the head as if to announce that it would last decades, maybe centuries, into an uncertain future. A fine set of wrenches, bearing dates or not, exudes the same sense of permanence.



11. Bow Saw

● The bow saw is a simple recipe for wood-cutting success: a ribbon-thin steel blade with sturdy teeth tensioned in a steel frame. And it's safer than a chain saw for removing tree limbs while standing on a ladder.

12. Jigsaw

● Because a jigsaw cuts with an up-and-down motion and its blade is comparatively narrow, it excels at cutting curves in wood, metal and plastic. Advanced models have an orbital setting that also moves the blade in a swinging motion for aggressive woodcutting.

13. Coping Saw

● A hand tool with a thin blade stretched in a C-shaped frame, the coping saw is also adept at intricate cuts: It is named for the technique of coping, or cutting, joints where two pieces of molding meet. As with any saw, choose a blade with more teeth for a finer cut, and one with fewer teeth for faster, somewhat rougher cutting. A blade with 15 teeth per inch, or tpi, should do the trick for general use.

17. Snips

● You don't have to be a metalworker to appreciate snips. This tool cuts sheet steel, copper and aluminum, but also rubber, heavy cardboard and plastic. Pro models have color-coded handles to indicate whether they are designed for left curves, right curves or straight cuts (red, green and yellow, respectively). Homeowners can get by with a single, all-purpose utility snip.

15. Hacksaw

● The fine-tooth blade of a hacksaw can cut through iron and steel, as well as through tough materials like hard plastics and cable. With a blade known as a carbide-grit rod saw, it can even slice ceramic tile. For metal, use a carbon-steel blade with 14, 18, 24 or 32 tpi. Opt for a bimetal blade for high-tension pro models, which exert tremendous tensile force in order to hold the blade arrow straight in tough cuts. The bimetal blade's carbon-steel back, bonded to a high-speed-steel front, can take the tension.

16. Crosscut Saw

● Even if you own an arsenal of power saws, an eight-point crosscut saw should be somewhere in your shop. It may not make the finest cut, but it's the perfect jack-of-all-trades saw for small jobs, like the occasional 2 x 4. Hold the saw so that its toothed edge is 45 degrees to the work surface, and start the cut by drawing the saw back very lightly. Use full strokes, engaging as much of the toothed surface as possible.



Side-Cutting Pliers

● Call them side cutters, linesman pliers or electrician's pliers. By any name, the heavy jaws and shears make them indispensable for cutting electrical cable and for pulling the steel tape used to fish wires through wall and ceiling cavities. Models rated as "high leverage" can cut nails and bolts, while those equipped with a die near the jaws can press together the crimp connectors used on grounding wires.



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18. Roundnose Shovel

● The roundnose shovel digs, cuts and pries, but, like any tool, its efficiency depends on you. Start with the shovel perpendicular to the soil, and use your weight and leg muscles, not your arms, to drive it down. To toss dirt, hold the shovel close and keep your forward hand on the blade socket. Bend both knees. If you're right-handed, point your left foot in the direction of the toss.

19. Needle-Nose Pliers

● When you need to fish a dropped screw out of a tight space, when working on electronics for example, there's nothing handier than a pair of needle-nose pliers. Their elegant shape is also perfect for fastening a wire to a switch or outlet receptacle: Grip the wire at the tip of the jaws and roll the pliers to produce a neat hook, then fasten the hook under the terminal screw.

20. Drill

● Cordless drills readily combine speed, power and portability—so for most of us, they've already replaced the corded variety. They also come with a clutch that disconnects the drive mechanism when it reaches a dialed-in force setting, preventing the user from stripping the screw. While 14- to 18-volt models can handle most jobs, some drills have voltages in the mid-20s or even 30s for power that rivals that of the corded product.

21.

Drill Bits

● For almost all general hole drilling, most of us can get by with a set of 15 or 18 high-speed-steel twist drill bits. You don't need to upgrade to a full set to deal with special circumstances, such as knocking a hole through a brick wall or boring through nail-infested lumber. Buy these expensive, single-purpose bits one at a time. As the years pass, the specialty bits add up, allowing you to tackle any job that comes along without a trip to the hardware store.

22. Locking Pliers

● An early multitool, locking pliers—patented in 1924—are sometimes known by the brand name Vise-Grip. They function like ordinary pliers but also as a wrench or welding clamp. Their powerful grip works well to remove stubborn nails or fence staples.

23. Level

● A 9-inch torpedo level is perfect for small jobs like hanging pictures, but you need a 2-foot or longer carpenter's model for bigger projects, such as leveling

appliances and bookshelves or plumbing posts to support a fence or mailbox. Another bonus: Long levels make a nice straightedge.

24. Circular Saw

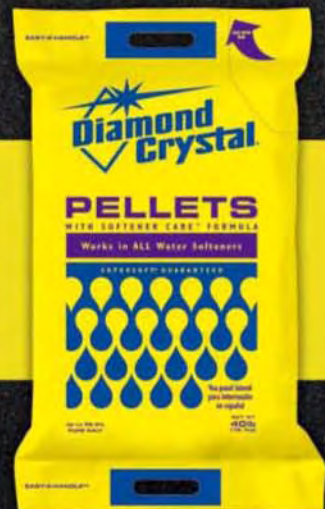
● Nothing beats a circular saw for speed and convenience when it comes to making straight cuts on a variety of materials. It can crosscut lumber or rip plywood, of course. But with a nail-cutting blade, a circular saw can also do demolition work; with an abrasive blade, it can saw through masonry and metal.





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TOOLS

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25. Spray Lube

● There are a lot of good spray lubricants, such as Liquid Wrench and Jig-A-Loo, but the most iconic is WD-40. The name stands for Water Displacement 40th attempt, since it took inventor Norm Larsen, founder of the Rocket Chemical Company in San Diego, 40 tries to find a formula to stop metal corrosion by displacing the water that causes it. WD-40 removes adhesive, cleans bike parts, stops squeaks and loosens rusted bolts. And it has a few more unusual applications: Police once used it to remove a naked burglar stuck in an a/c vent.

ARCHITECTURAL SALVAGER

Eddie Hibbert

MUST-HAVE TOOL: dust mask (28)

For the past quarter-century, Eddie Hibbert has patiently restored old mantels, doors and other brownstone artifacts, becoming a living legend in the New York City salvage community. Despite the friendly, informal atmosphere around his Brooklyn shop, the work is made hazardous by wood chips, flying debris and lung-choking dust—some of which emanates from pieces that predate the 1978 U.S. ban on lead-based paint. “That stuff will kill you,” Hibbert says. That’s why his crucial tool isn’t a scraper or a sander—it’s a respirator. The National Institute for Occupational Safety and Health recommends a disposable or cartridge-type half mask (not pictured) with a P100 rating to remove lead dust. For Hibbert, buying the best respirator he can find is money well-spent. Breathing new life into old architectural pieces is Hibbert’s job—but, he says, protecting his lungs is more important.

29. Nail Set

● A nail set allows you to countersink nailheads without damaging the surrounding surface, then conceal the holes with wood filler. While you can use a set that’s one size larger than you need, don’t try to use an undersize one—this can damage the tool’s cup-shaped tip. To ensure you’ve got the right size, get a set of four: $\frac{1}{32}$ -, $\frac{1}{16}$ -, $\frac{3}{32}$ - and $\frac{1}{8}$ -inch.

30. Machinist Vise

● Whether stationary or swiveling, a vise is like an extra set of (really strong) hands for securing your work. Cast-iron models function well for most applications, but buy a forged-steel vise for anything heavy-duty. If you cut a lot of pipe, choose a vise with V-shaped jaws to grip round material. For moderate metal pounding, choose one with an anvil behind the jaws. While it’s no substitute for a blacksmith anvil, it is handy for small projects.

26

Tape Rule

● A measuring tape is a spring-loaded marvel, combining compactness and speed. Poke its tip down to the intersection of floor and wall, then bend it up the wall to measure ceiling height. Extend it horizontally and it’s stiff enough to bridge several feet of open air. A 25-foot model is sufficiently long to handle most home construction jobs, yet small and light enough to stash in a nail pouch or clip to your blue jeans.

Classics

27. Hammer

In 30,000 B.C., someone altered the destiny of the human race by lashing a stick to a rock, a refinement that increased the user’s strike speed and accuracy. The hammer was born. Later, stone begat bronze, begat iron, begat steel—a material that could be forged into a ruthlessly efficient shape. Yet, after all these millennia, the wood handle remains, preferred by craftsmen for its light weight, shock absorbency and balance. It was the post-World War II housing boom

that finally transformed the profile of the modern hammer. Can’t-frame-’em-fast-enough carpenters on the West Coast needed still more speed, so they grafted elements of heavy-rigging hatchets onto claw hammers. The result is the beefy, all-business, California-style framer, a swift, long-handled striking tool with a vicious claw. A nail gun might be fast, but nothing beats the feeling of sinking a nail in two or three clean hits.







FURNITURE MAKER

Keith Fritz

MUST-HAVE TOOL: wood chisel (31)

"My favorite tool is a big, flat 10-inch chisel with a boxwood handle," woodworker Keith Fritz of Jasper, Ind., says. "It's English, made in the 19th century and has a good weight to it. That's the tool in my hand the most." Fritz grew up in the no-stoplight community of Siberia, Ind., where both his father and grandfather farmed land and worked wood. As a high school student, he won back-to-back annual statewide competitions, one of them for an intricate Chippendale-style secretary with slots, drawers and secret compartments. Planning to study theology, he moved to Washington, D.C., and attended Catholic University but heard the call of furniture-making instead. Bill and Hillary Clinton own one of his dining tables, which sell for up to \$30,000. A few years ago, Fritz moved his shop from the seminary's basement to Jasper. There, he builds furniture inspired by old designs using mostly hand tools—and never a scrap of sandpaper. "You can tell an antique is real by looking at the tool marks," he says. "Pre-1880, there was no sanding involved. I can get the same effect with a really sharp chisel."

32. Chalk Line

● As technology goes, the chalk line is incredibly simple—a cranked spool of string that runs through a reservoir of powdered chalk. But for marking a straight line when ripping long boards, or for laying out wall plates while house framing, nothing fancy works better.

33. Allen Wrench

● Also known as hex keys, Allen wrenches are not wrenches in the conventional sense but are more like screwdrivers, as they fit inside the fastener head rather than surrounding it. They're handy for knock-down furniture and setscrews on faucet bodies.

34. Earmuffs

● Hearing damage is permanent, but it's also preventable. Earmuffs, as opposed to earplugs or headphones, provide maximum protection. Really loud shop tools, such as chain saws and circular saws, may operate above

100 decibels—and noise higher than 85 decibels begins to cause damage. Choose a product that has a high noise-reduction rating (NRR)—preferably in the range of 23 to 33.

35. Flashlight

● A flashlight is useful for more than emergency power outages. Select a freestanding swivel-head model for brightening dark work areas. Choose one with a built-in magnet to adhere to pipes, steel beams or the inside of an appliance that you are

repairing. For truly rugged use, opt for an LED light with as high a drop-test rating as possible: Some industrial-quality flashlights are rated for falls as high as 25 feet.

36. Bow Rake

● Rugged and simple, the bow rake remains the best device for raking heavy material, such as gravel or tangled sticks. The bow acts as a shock absorber, protecting your arms while you work. If you turn it over, the straight back can also be used to level soil.



37. Volt/Ohmmeter

● This tool is far more versatile than its two-part name suggests. Aside from measuring voltage and resistance (ohms), it also measures current flow (amperage), and most modern versions emit a tone to signal a complete circuit (continuity).



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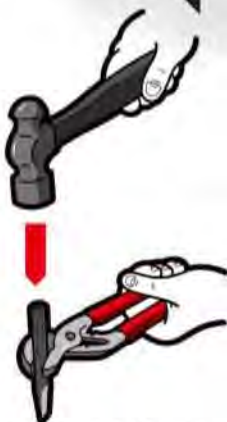


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Tip



38. Cold Chisel

- Use a cold chisel to chop through bolts, rivets and pins and to cut cold (as opposed to torch- or forge-heated) metal. Strike it with a ball-peen hammer, preferably one with a head $\frac{1}{8}$ inch larger than the end of the chisel. You can get a better view of the tip by gripping the body with tongue-and-groove pliers. Always wear safety glasses when striking a cold chisel, and never use it on stone or concrete.



39

Ball-Peen Hammer

- The face of a ball-peen hammer strikes cold chisels and punches, while the dome-shaped end rolls over the edges of rivets (peening) or works curved sheet metal. The hammer ranges in size from 4 to 50 ounces (with large models serving as blacksmiths' hammers), but the 16-ounce size works well and fits in crowded toolboxes.

40. Multibit Screwdriver

- Because your screwdriver tip should match the head of whatever screw you're turning, a screwdriver with interchangeable tips is a compact, convenient alternative to a drawer full of tools. Plus, a handheld screwdriver often gets small jobs done faster than a cordless one.

41. Gooseneck Bar

- This is also called a wrecking bar—for good reason. A curved neck gives the steel tool incredible prying power, perfect for separating two pieces of lumber that are nailed together. Rely on small models up to 18 inches long for light-duty demolition, but graduate to a 36-inch bar for the big stuff.

42. Utility Knife

- A utility knife cuts drywall, slices string and duct tape and sharpens carpenter's pencils. What more utility could you want? Okay, better blade storage. But advanced designs have swing-out blade loading, as opposed to a cranky, hollow, two-piece body.

43. Pry Bar

- Shorter and flatter than a gooseneck bar, a pry bar is most useful for removing trim and paneling. Many variations exist, but the most versatile types have at least one nail-pulling slot (two is better).

44. Square-Nose Shovel

- The square-head design makes this shovel ideal for scooping debris and measuring material. When using it to place concrete, work the back of the blade against the inside surface of a slab form to consolidate concrete there. The long, flat blade is also handy for popping drywall off walls during demolition.

45. Extension Ladder

- Ranging in length from 16 to 40 feet, extension ladders put most projects safely within reach. To ensure you don't buy a ladder that comes up short, buy one at least 7 feet longer than the height of the object you need to reach. When in doubt, check the manufacturer's label to compare the ladder's length to its actual reach.



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Classics
46.
Tongue-and-Groove Pliers

Howard Manning, chief engineer for the Champion DeArment Tool Company, invented tongue-and-groove pliers in 1933, improving on standard designs by adding length and leverage and increasing jaw width. The new tool caught on among car mechanics, who used it to repair water pumps. In 1953, the company's engineers redesigned the tongue and groove, undercutting the tongue to give the tool a firmer bite—a tweak that prevents it from slipping and busting your knuckles. They've made other improvements over the years, but the instantly recognizable grip color—probably the only hand-tool color ever trademarked—has remained the same. "Back in the early 1950s, all the plier manufacturers started putting colored PVC on their grips," says Bill DeArment, great-grandson of the company's founder. Crescent chose red; Stanley Tools, yellow. DeArment's father and uncle picked a beautiful sky blue that no one else had—and the company has used that color since 1956. In 1962, Champion changed its name to Channellock; DeArment is the president and CEO. And today, tongue-and-groove pliers are an essential for mechanics, farmers, plumbers and average joes everywhere.



47. Pick

● A pick is like a pipe wrench—not very versatile, but when you need it, nothing else works nearly as well. If you spend most of your time breaking up hard, rocky soil, get a railroad pick—the type with two pointed ends, or a narrow chisel tip on one side and a pick on the other. Although using a railroad pick to break soft and medium-hard rock has become a dying art, it can be done when the rock already has a crack into which you can drive the tip of the pick. The tool can also be used for chopping through asphalt, and it's effective at severing

roots when equipped with a pick blade on one end and a mattock on the other.

48. Stepladder

The safest way to reach things inside the house is with a properly sized step ladder. Although they range in height from 3 to 20 feet, the most useful ladders are those in the 6- to 10-foot range—tall enough for you to change light bulbs but not so large as to be unwieldy. If you need to gain height in an awkward location, such as on the stairs, a multiposition ladder solves the problem with hinges and telescoping legs that adapt to uneven footing.

50. Extension Cord

● Large jobs require corded tools—and an extension cord to match. The minimum spec for most DIYers should be a 14-gauge cord rated for 15 amps. But a 12-gauge cord is better, and a 10-gauge contractor-quality cord better still, because it ensures minimum voltage drop along its length.



CATTLEMAN

Mark Roeber

MUST-HAVE TOOL: rope (49)

"Everything we do involves some type of tool," says Mark Roeber, a fifth-generation cattleman who runs a cow-calf operation in Paonia, Colo. "It's the lifeblood of how we get things done." Roeber reproduces and raises cattle on a ranch that has been in his family since 1889. But for six months of the year, his 400-odd head graze on 90,000 acres of federal land, 60 percent of which is roadless wilderness. So Roeber and his partners work on horseback, relying on one of the oldest and most versatile tools known to man: rope. Using both nylon and cotton ropes, Roeber lashes down packs, leads his horse and, when he's breaking in a new animal, rigs up a bitless bridle known as a bosal hackamore. He rides with a 35-foot lariat tied to the fork of his saddle. "Out on the range, that's how you catch livestock for doctoring or pull them out of bogs," Roeber says. When he rides off to repair fences, he loads a packhorse with a roll of wire fence, fence-mending tools and a folding pruning saw for clearing brush along the way. And he never parts with his folding knife: "I use it to get out of a wreck with a horse if I get caught up in the lead rope, for digging splinters out, sharpening a pencil, even writing on a tree to leave somebody a note."



Paranoid by Design

FORM FOLLOWS FUNCTION AT AMERICA'S NEW INFECTIOUS DISEASE RESEARCH LABORATORY, WHERE SCIENTISTS WILL STUDY THE SECRETS OF THE WORLD'S DEADLIEST PATHOGENS.

THE INTEGRATED RESEARCH FACILITY at Fort Detrick, Md., doesn't look menacing. The three-story glass-and-brick structure, which could fit seamlessly into any suburban office park, is typical of buildings designed by architects who read studies linking sunlight with worker productivity. The leather chairs in the atrium seem to encourage lounging. The National Institute of Allergy and Infectious Diseases, which operates the IRF, plans to install a coffee bar in the atrium.

But cocooned within the nearly completed \$105 million facility is a laboratory built like a submarine—11,125 square feet of airtight, carefully pressurized space. As soon as next spring, 30 doctorate-level scientists wearing protective suits and hoods will conduct groundbreaking research in these rooms, trying to determine how lethal infectious diseases kill their hosts.

Hemorrhagic fevers like Marburg and Ebola, which are caused by viruses, are among the world's most horrific afflictions. For about seven days after infection, patients suffer from flulike symptoms, but as the virus multiplies, blood starts to seep from the skin,

by Joe Pappalardo photographs by Noah Sheldon

A biohazard suit protects Peter Jahrling, chief virus hunter at the Integrated Research Facility in Fort Detrick, Md.

Opposite: The air-lock entrance to the lab's hot zone.



mouth, eyes and ears. Internal organs hemorrhage into bloody, shapeless masses. Some of these fevers kill up to 90 percent of those who contract them, and they can be passed along by close contact with bodily fluids, maybe even by a sneeze.

Scientists still don't know much about how these rare but deadly diseases operate. If they take root in America—carried by unsuspecting travelers or by terrorists—the medical community would have no vaccines to halt their spread. And there are only a handful of laboratories in the world equipped to experiment with these highly communicable pathogens; none has the sophisticated diagnostic gear that is being installed at the IRF. Lessons learned here could one day mean the difference between an outbreak and an epidemic.

The best time for an outsider to visit the IRF is before it goes hot—that is, now, before the deadly bugs are brought to the site. “It’s the *only* time,” says Jason Paragas, the facility’s associate director for science. Paragas is one of the 30 staffers who will work in the highly restricted lab. Quietly friendly, with a stout frame and easy disposition, he talks and moves with deliberation and does not seem to have an impulsive bone in his body. His dress is tidy and Maryland casual—loose button-down shirts, but never a tie. The 37-year-old researcher has spent nearly three years working on the new facility, so he makes a highly informed tour guide.

Paragas is standing in what will be the dividing line between two labs—an outer lab rated to handle dangerous infectious diseases and an inner lab designed for the worst pathogens in the world. The outer area is the medical research equivalent of a maximum-security prison—Biosafety Level 3. The inner sanctum is supermax, or BSL-4. Researchers can study bubonic plague at level 3; Ebola and other killers that are transmissible and currently incurable must be quarantined at level 4. The institute is so security-conscious that it asked *POPULAR MECHANICS* not to identify the floor on which the BSL-3 and BSL-4 labs are located.

To enter the restricted BSL-4 lab, Paragas first has to pass through two stainless-steel doors set up as an air lock. He punches in a code that deactivates the magnetic lock on the first door. The keypad also alerts the building automation system (BAS) that the air pressure is about to change. The BAS adjusts the airflow, increasing the pressure in the BSL-3 area and decreasing it in the air lock. Once Paragas is ready to enter BSL-4, the BAS will ensure that high-pressure air in the air lock flows into the low-pressure, high-security lab, trapping airborne pathogens. The deeper the level of containment, the lower the pressure. “Biocontainment sucks,” Paragas says. “Any breach is sucked in by the negativity.”

The air-lock door closes with the sound of an overworked drill, which is caused by the rapid inflation of a rubber bladder that seals the smooth edges of the door. Once the facility is operational, the air lock will also serve as a decontamination shower. For 7 minutes, vertical banks of nozzles will spray water and virus-killing chemicals over exiting scientists’ hoods



and suits before the door to BSL-3 will open.

Paragas sees the glow of a green light: The BAS is allowing him to push open the second door and enter BSL-4. Fluorescent lights, hanging in airtight boxes to prevent microorganisms from collecting on edges, reflect off easy-to-decontaminate stainless steel. The walls have a glistening sheen from the layers of epoxy potting compound that form a continuous seal across every surface. Light fixtures and electrical outlets that penetrate the seal are housed in airtight boxes and lathered in epoxy. Construction workers went so far as to strip insulation from the ends of wires that emerge from the walls and seal the tips with the compound.

The IRF’s architects designed everything inside BSL-4 to this level of security. Even fire-sprinkler heads are fitted with valves to prevent viruses from making an unlikely swim up the pipes. At the conclusion of experiments, lab technicians will rinse metal equipment with chemicals and then further purify the gear with an autoclave bake. “We are in control of our agents at all times,” Paragas says.



• **Fresh air:** A labyrinth of ducts guides air in the lab through banks of powerful filters, each of which removes more than 99 percent of particles larger than 0.0003 mm. Staff say air leaves the building cleaner than it arrives.

•• **Clean water:** Water and decontamination chemicals from sinks and showers collect in three 1500-gallon tanks in the facility. These tanks heat waste fluids to 250 F, killing anything that survives the disinfectant rinse.

••• **Good views:** Staff will slide infected monkeys into the tube of this X-ray machine, the first to be adapted for use in high biocontainment. Scanners move around the tube for 360-degree views of the progress of a disease.

Once the BSL-4 lab goes hot, the animal testing will begin. Since primates react to diseases in ways similar to humans, they are the subjects for many level-4 experiments. The IRF staff is acutely aware of the sensitivity of using monkeys in medical research, but note that the threat posed by potential plagues demands real-world study. IRF staff say they handle the animals with the care they would provide human patients. "We liken this to a monkey intensive-care unit," says Peter Jahrling, the IRF's director.

Jahrling has spent more than three decades studying infectious diseases, yet he admits that the way they work remains a mystery. "The animals die of multisystem failure," Jahrling says, "but what initiates the terminal events?" To answer that question, researchers here will rely on medical scanners housed in four adjacent rooms in the BSL-4 bubble. No other biocontainment facility employs this type of equipment.

Each machine generates different information—a positron emission tomography (PET) scanner measures tissue and

organ damage, while a magnetic resonance (MR) instrument is used to discern details about the vascular system. The X-ray machine will identify abnormalities in the chest and lungs; CT scans will show whether there is swelling in the brain. Snapshot by snapshot, the combination can reveal how hemorrhagic fevers like Ebola dismantle a healthy body.

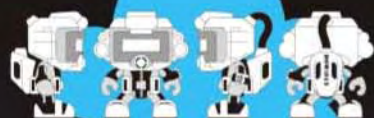
Engineers at Philips Medical Systems modified the four scanners for use in this BSL-4 facility by moving the bulk of the hard-to-seal electronics outside the hot sections of the lab for maintenance. They also installed laser and infrared tripwires that will automatically halt moving parts on the scanners before they make contact with barriers between the level 4 hot zone and the outside world. Architects designed the rooms around the scanners: Copper sheets in the floor of the MR room, for example, shield the machine from radio-frequency interference. These powerful medical devices present their own dangers, such as the radioactive materials used in the PET scanner and MR magnets strong enough to pull rings off fingers or metallic replacement hips out of joints. "In here," Paragas says, "there are hazards heaped on hazards."

To gather data on the stages of an infectious disease, scientists in other labs typically expose a number of animals to the same pathogen and then kill the subjects at intervals, examining the corpses to chart the disease's progress. But thanks to the scanners, IRF staff will follow the course of a disease in a single animal, requiring fewer to be sacrificed. Data from an individual primate patient is also more consistent.

The IRF's initial tests will allow diseases to rage unchecked through their animal hosts. Researchers will wheel caged monkeys from holding areas into the hot sections of the lab where they will inject them with highly concentrated viral doses. After allowing about a week for the viruses to take hold, handlers will sedate the monkeys and place them in the tubes of the imagers. Technicians outside the BSL-4 area will operate the scanners remotely, rotating them around a tube to peer through skin and bone to measure where oxygen and blood flows are failing, which will indicate what organs the viruses are attacking—and in what order. "Now we are shining a flashlight on the subjects to find the viruses," Paragas says. "By using these scanners, we'll be able to illuminate the whole body. There will be nowhere for the viruses to hide."

Once base-line knowledge of a disease's progress has been established, scientists will test the animals' reaction to drugs, vaccines and therapies. Researchers want to identify infectious diseases that run a similar course, so that the same vaccines and treatments can be applied to numerous outbreaks. "We can't afford to make a vaccine for every emerging disease," Jahrling says.

The first rule in any fight is to know the enemy—and that places this outwardly normal office building on the front line of a war against invisible foes that can mutate into more powerful strains. Jahrling, one of the nation's most seasoned virus hunters, has no illusions as to which organisms have the upper hand: "The bugs are always one step ahead." **PM**



Wet welders work in offshore oil fields as deep as 400 feet, building and repairing undersea infrastructure. (Sorry, kids, you can't buy this exclusive PM action figure, devised by Jeremy Madl at Mad Toy Design. It's ours.)

TEN CAREERS FOR RIGHT NOW

Character Concept by Mad Toy Design

Rendering by Jeremy Cook

Undersea Welder

Arc welding underwater with electrodes carrying 185 amps might seem unwise, but deep-diving wet welders do it every day. They build and repair pipelines and oil platforms—in January 2009 there were 313 new bids worth \$484 million in the western Gulf of Mexico alone. Dusty Harrison, placement director for a Florida school called the Commercial Diving Academy, says, “There’s no telling how much work there is,” thanks to a decade of hurricanes and a boom in oil exploration. During the Gulf’s hurricane season, some welders work in West Africa and Asia.

How to Do It: Oil companies hire dive outfits with welders certified by the Association of Commercial Diving Educators. Schools such as the Commercial Diving Academy and New Jersey’s Divers Academy International have four- to five-month certification courses. Swimming ability and a high school diploma are prerequisites; scuba diving isn’t.

Earning Potential: Right out of school, you’ll pull in \$17 to \$20 an hour. “After two and a half or three years, that typically doubles,” Harrison says.

By Claire Martin

Want a job?

Investment banks aren’t hiring right now, but if you’re interested in the new wave of energy exploration (underwater or on wind-swept ridges), in digital tech (like game design and 3D sportscasts) or even in building space-ships, we have some leads for you. Welcome to the PM job fair.

cent of their clients in 2008 used green building elements. Despite the housing slump, Kaufmann says her 15-person staff is swamped: “We have more projects than ever before.”

How to Do It: Earn a master’s from one of the 61 U.S. architecture programs that offer classes with a green bent. (Yale has a joint degree in architecture and environmental management.)

Earning Potential: Nationally, staff architects earn about \$45,000 to \$100,000. Architects who own their firms can make much more.

Zero-Energy Home Architect

Some houses now being built make as much energy as they consume. They rely on equipment such as solar cells to generate power, while using efficient design to keep consumption down. Michelle Kaufmann, an architect in Oakland, Calif., is bringing the zero-energy idea and other forms of sustainable design to prefab houses such as her mkLotus, a small, one-bedroom home. (Kaufmann worked for architecture legend Frank Gehry before founding her own firm in 2002.) Kermit Baker, an economist for the American Institute of Architects (AIA), says, “Sustainability and architecture are now intertwined.” In a recent AIA survey, architects reported that 47 per-



Combined Heat and Power Mechanic

Jim Bondi is an old-school electrician who embraces new-school energy production. After eight years working on projects that included solar installations, he joined Pennsylvania-based E-Finity, designing combined heat and power (CHP) plants. A CHP unit saves energy by burning fuel to produce electricity and using the excess heat for climate control and producing hot water. "With the nation's rising energy demand and the increase in environmental stewardship, CHP is an economic and environmental no-brainer," Bondi says. The Department of Energy hopes the industry will grow enough to add a million workers by 2030.

How to Do It: CHP suppliers provide training. Electricians and mechanics with experience on jet and helicopter engines, which are similar to CHP turbines, find their skills are a natural fit.

Earning Potential: Salaries are \$30,000 out of the gate; they top out at \$75,000.

Energy Engineer

When the Coronado naval base in San Diego wanted to shrink its energy consumption, it turned to the consulting firm Tetra Tech, whose energy-efficiency staff has grown sixtyfold in the past decade. "The naval base is like a small city, with office buildings, a supermarket, bowling alleys," says Linda Hunter, a Tetra Tech energy engineer who was brought in to boost efficiency on the base and its two aircraft carriers. Energy engineers may recommend new air-conditioning equipment or solar-powered streetlights, or they may design entire renewable-energy systems, such as harnessing methane from a landfill to generate electricity.

How to Do It: Earn a degree in chemical, mechanical, electrical or civil engineering—or a newer specialty called energy resources engineering. A Certified Energy Manager (CEM) certification is useful; it demands expertise in subjects like indoor air quality codes and standards, thermal energy storage systems and energy economics.

Earning Potential: Salaries start in the \$50,000 range; with a master's, you'll get bumped up to around \$70,000. Managers can pull in more than \$100,000.

the private sector: "If your business's survival depends on cyber security, you're going to start looking for unconventional answers," he says.

How to Do It: Programming skills are a must; a degree in computer science is helpful in landing a job. The Center for Cyber Defenders Program at New Mexico's Sandia National Laboratories offers specific red-team training.

Earning Potential: \$60,000 to start on the government and government-contract side; six-figure salaries are common in the private sector.

3D Sports Tech

Many fans already say they get a better view of sports events watching TV than sitting near the action, but 3D cements the argument. At least, that's the view of Steve Schklair, CEO of Burbank-based 3ality Digital Systems, a company specializing in 3D technology and production. "If you've got a camera down low next to the green and the golfer is putting uphill, you can actually see the

roll of the green while he's putting," he says. Ray Hannisian, the company's lead stereographer, uses software running complex sets of algorithms to fine-tune and synchronize the depth readings of as many as 10 cameras during events. The technology raised its profile during this year's national college football championships, which 3ality shot and broadcast live to 63 movie theaters in January. Such broadcasts will soon be coming to a living room near you: American consumers have already bought 1.4 million 3D-compatible televisions, and every major electronics manufacturer is now producing such sets. Of course, the best-known 3D arena remains moviemaking. More than a dozen 3D movies are scheduled for release in 2009.

How to Do It: You can master 3D still photography on your own using a program like HumanEyes Capture 3D Software. Also, take classes in digital videography (art schools and university film programs offer them), then look for a job as a 2D cameraman. "With digital technology, you can learn a lot about 3D while you're actually shooting," Hannisian says.

Earning Potential: Salaries start at \$50,000 and can go as high as \$150,000 for television work. For the elite earners in 3D movie production, Schklair says, "There is no limit."



Digital Detective

Red teamers focused on digital security are hired to hack into computer systems to uncover vulnerabilities. The Department of Homeland Security plans to quadruple its cyber-security staff this year. Mark Mateski, a red teamer and the managing editor of *Red Team Journal*, says, "You'll find a lot of red teamers working in war gaming and cyber security in the government-contracting world." Even bigger growth may be coming in



3ality TS3 Camera Rig

Wind Explorer



Siting a wind farm takes engineering chops, anemometers, GPS skills and, sometimes, zinc oxide on your nose.



When civil and environmental engineer Mathias Craig arrived in Nicaragua in 2004, he found a stretch of Caribbean coastline where transportation consisted of horses and boats and there wasn't a single light bulb. "It was like the Wild West 200 years ago," he says. As founders of the nonprofit Blue Energy Group, Craig and his brother organized volunteers to build wind turbines to catch the Caribbean trade winds and supply several communities with electricity. Hugh Piggott, a Scotland-based wind-energy pioneer, has worked on similar projects in Zimbabwe, Peru and Sri Lanka. "One of the places wind energy is expanding most rapidly is the developing world," he says. "The number of people in the world who don't have utility power is actually increasing." That's because the population in many regions is growing faster than grid lines and new power plants can be constructed. Craig and his staff

of 32 have already installed nine turbines in Nicaragua. They've also scouted sites in West Africa, and they're in talks to expand into Honduras and Guatemala.

How to Do It: Texas Tech University's Wind Science and Engineering Research Center offers a summer internship for undergrads and has one of the country's few Ph.D. programs in the field. However, it's possible to jump in without an advanced degree. Piggott teaches turbine-building seminars worldwide; Blue Energy has an apprenticeship program in Nicaragua.

Earning Potential: Nonprofit firms based in developing countries pay from \$1000 to \$4000 per month. Annual salaries in the U.S. currently range from \$35,000 to \$55,000.

Fabricator of Carbon-Fiber Spaceships and Planes

"We're like the shipbuilders of the modern era," Reuben Garcia says. As head composite fabricator at XCOR, an aerospace company in Mojave, Calif., Garcia is deeply engaged in the race to make ships capable of carrying tourists into space. Garcia and his team take the plans drawn by XCOR's engineers and make them real, using lightweight carbon composites similar to the materials used everywhere from Formula One race cars to high-end fishing rods. Composite structures are built up layer by layer, and Garcia's high-tech creations are shaped largely with such low-tech tools as squeegees filled with epoxy resin. XCOR, which plans to conduct test flights to space by 2011, is situated in a tiny town that has become a hotbed for spaceship and small-airplane construction. "You can walk into any of the 20 or so companies here and have a job in an hour," says Jon Sharp, owner of Nemesis Air Racing, which builds racing planes.

How to Do It: Many companies will train newbies. However, community colleges can offer a head start with introductory courses in composite fabrication.

Earning Potential: Pay starts low but can climb to \$20 per hour. Managers who go on to earn engineering degrees can make up to \$100,000 a year.



XCOR
Rocket Plane

Battery Engineer

Will Gardner was a freshly minted college graduate with a degree in mechanical engineering when he was hired by Duracell. "I had no idea what a battery company could want with a mechanical engineer," Gardner says, but he was drawn to the field, which combines elements of electrical engineering, chemistry, materials science and, yes, mechanical engineering. "You need to know something about each of them in order to succeed," he says. Today, Gardner leads a team that designs, builds and tests batteries for hybrid electric cars at A123 Systems, a fast-growing firm based in Watertown, Mass. A123's clients include Chrysler, GM and automotive upstarts Think and Better Place, and the company's staff has jumped from 150 to 2000 in the past three years. Ann Marie Sastry, who directs the University of Michigan's master's program in energy systems engineering, says, "The DNA of the automobile is changing, which means the composition of the workforce has to change." Sastry also runs her own battery company, called Sakti3. "We're hiring," she says. "It's a great time to be a battery guy."

How to Do It: A bachelor's in math, materials science or engineering is essential. Sastry's program is very highly regarded: "Students are getting jobs even before they finish their studies," she says.

Earning Potential: To start, \$50,000 to \$60,000; at the senior level, \$95,000.



Independent Video-Game Designer



It took Kyle Gabler just four days to come up with the concept for his first video game, and, frankly, it didn't seem like a blockbuster waiting to happen: The protagonists are gobs of goo. But in the growing world of independent game design, execution is key—and Gabler created a look that has drawn comparisons to filmmaker Tim Burton, supporting a story filled with intrigue and humor. The prototype became an indie hit, and in October 2008 Gabler launched the Nintendo Wii game *World of Goo* (above). In an era of sequels (a dozen *Medal of Honor* games, eight iterations of *Grand Theft Auto*), the industry needs fresh ideas—and supplying them has traditionally been a designer's main job. But as Simon Carless, publisher of the industry website Gamasutra and a former lead designer, says, "Now designers also need practical skills. You need to be able to *make* the game."

How to Do It: More than 200 schools offer game-design degrees, including the Art Institute of Portland, which graduates students with a B.S. in Visual and Game Programming. But consumer tech is so good now that you may be able to go it alone. "You can make stuff in your bedroom that's as good as what people are making professionally," Carless says. Art, music and coding skills are all critical.

Earning Potential: Staff designers start at an average of \$62,000, according to a survey by gamecareerguide.com. On your own, it's feast or famine. Gabler was incomeless while designing *World of Goo*. In January, it became the 10th-best-selling PC game on the market.

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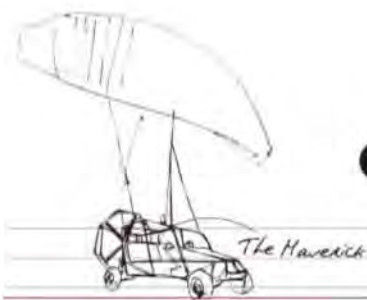


THE MISSION

Popular Mechanics / May 2009 PAGE: 103

In the 1950s, Nate Saint, adventure pilot and Protestant missionary, barnstormed the Amazon. Now, his son plans to transform jungle aviation and save lives—with help from a flying car and a prayer.

WRITER: *Logan Ward*



"GATHER AROUND, EVERYONE," Steve Saint says. "Let's say a prayer about these flights." Saint, a thin, gray-bearded 58-year-old, is wearing khakis and a salmon-colored shirt and holding a red crash helmet with a radio headset. He is standing with a dozen employees and well-wishers in front of a candy-apple-red vehicle parked beside a crumbling strip of tarmac at a sleepy little airstrip near Dunnellon,

Fla., 87 miles northwest of Orlando. The contraption looks like a dune buggy, but one with a propeller in back like an Everglades airboat and, billowing above, a rainbow-colored flex wing—essentially a double-canopy parachute—held aloft on a mast.

"Jay, how about you?" Saint says, peering through wire-rimmed glasses. "You built this thing. You know what can go wrong." Jay Dyck, the project's chief designer, steps forward, closes his eyes and drops his chin. "Father and God," he booms, warming to his task, "we have tried to do our best." A prop plane buzzes into the blue Florida sky behind him. "Father, we leave it to you. Help Steve stay alert and be safe." His entreaty done, Dyck scrutinizes the driveshaft and chute lines one last time.

"You can design something on paper, but it's just a thing until you get it in the air," he tells me, his animated face growing sober. "If something goes wrong up there, you can't park it. You're gonna come down."

Saint climbs into the driver's seat. The Federal Aviation

↑ 2009 Steve Saint's flying vehicle may enter service by the end of 2009.

← 1956 Saint watched daily as his bush pilot father flew this Piper Cruiser. The Amazonian Indians called it a wood bee.

Administration approved the craft for testing a couple of days earlier, and this will be its first official flight, though the team briefly flew earlier versions. Stretching across the aluminum dash in front of him is **EXPERIMENTAL** in bold, black stick-on letters.

Steve Saint is a missionary—and yes, that's his real name. He's also a pilot, a former real estate developer and the one-time owner of a lime rock mine near Ocala, Fla. He grew up in Ecuador, where his family moved in the 1950s as Protestant missionaries to work with indigenous peoples in the Amazon Basin. At first, they focused on Quechua Indians. But it was another group, the Huaorani, then referred to by outsiders as "Aucas" or "savages," to which the Saint family would become linked by tragedy. Half a century ago, the story became a subject of articles and sermons, and Saint recently wrote a book and helped make two films about it.

Today Saint is working to fulfill a long-standing promise he made to the Huaorani: helping them find a better way to travel in a land where villages can be a month's walk from medical help. The bush plane is considered the modern missionary's pack mule, but Saint's group, the Indigenous People's Technology and Education Center (I-TEC), is trying to build a more versatile vehicle. I've come to see I-TEC's progress with the hybrid aircraft they call the Maverick. Saint says the vehicle will hit highway speeds on pavement, burn up dirt tracks like an all-terrain vehicle and, when the road ends, take to the air. The finished craft should have the carrying capacity of a Cessna 172—fuel plus 550 pounds—without the plane's expense and need for an airstrip. And nonpilots will be able to fly it. In Huaorani territory right now, Saint says, "If you get sick and don't have an airstrip, you're dead."

It's time for the flight. "Clear!" Saint yells, and the 128-hp Maverick roars to life, its five-bladed carbon-fiber prop blasting sand and grass in its wake. The buggy chugs across the weedy runway as the ram-air cells in the canopy fill. The idea that a colorful curl of ripstop nylon attached by spaghetti straps can lift an 1100-pound off-road vehicle seems almost absurd. But soon the front wheels are leaving the ground, and the gleaming frame is climbing—100, 200, 300 feet—into the white glare of the sky.

➤ STEVE SAINT WAS 5 YEARS OLD when his father, Nate Saint, a man of restless energy and a big-toothed smile, launched a secret plan that he and four missionary buddies earnestly dubbed Operation Auca. Saint was flying for the Mission Aviation Fellowship in the eastern lowlands of Ecuador. In 1955, using a trick called the bucket drop that he had dreamed up as a young pilot back at Wheaton College in Illinois, Saint began lowering gifts to a Huaorani village from the cockpit of his yellow Piper Cruiser. A partner would spool out 1200 feet of cord with a canvas bucket

filled with axe heads, colorful buttons, machetes and more. Then Saint would cut tight circles in the air until the line formed an inverted cone with the bucket hanging at its point—motionless—just above the ground. One day, the Huaorani filled the bucket with their own presents—a toucan headdress, smoked woolly monkey meat and a live parrot that Nate gave to Steve as a pet. The time had come: If the five evangelists were ever going to bring Jesus to the Aucas, they would have to meet them face-to-face.

On Jan. 3, 1956, Nate pointed the nose of his plane toward a narrow gap in the jungle canopy cut by the path of the muddy Curaray River. He aimed for a sliver of beach along the river's south bank, hoping that his wheels wouldn't sink in soft sand, or, worse, flip his plane. The wheels bit into the sandbar and rolled 600 feet, stopping a pebble's toss from the water's edge. Over the next few hours, the group ferried in food, two-way radios, materials for building a treehouse shelter, and gifts seemingly suited for a child's Christmas stocking, including a harmonica, a yo-yo and a View-Master with picture reels.

Back in Shell Mera, a former oil settlement with a gravel airstrip, Steve waited for Nate's plane to reappear over Penny Ridge, as it did every afternoon. Why isn't daddy coming home? the boy wondered. That evening, the missionaries radioed Nate's wife, Marj, to say that they had landed safely and made camp. After several days, a young man and



↑ Nate Saint dreamed of using his bucket-drop technique to whisk the sick or wounded from trackless forests to medical clinics. He tested the idea by airlifting the family dog. ➔ Steve Saint, left, learned jungle arts, including how to load poison darts in a blowgun, from Huaorani hunters.



two women, naked except for strings around their waists, stepped out onto the sand. The excited Americans tried out the few Huao words they knew and gave the curious trio lemonade and peanut butter sandwiches. Nate took the man, Nenkiwi, up in his plane, buzzing the village as Nenkiwi yelled down to his clansmen below.

Three days later, Nate flew over the village and saw a group of about 10 Huaorani moving swiftly along a trail leading toward the beach. He radioed Marj excitedly: "Looks like they'll be here for the early afternoon service. Pray for us."

Nate promised to radio again at 4:30 pm. The call never came. A search party found the plane five days later looking like a skeletal bird, its fabric cover shredded. They found the bodies of the missionaries in the river and buried them by the water's edge. The men had been speared to death.



→ Saint describes the Maverick's design to the author. The craft gets airborne in just 100 feet; a future version will be equipped to land and take off from the water.
→ Mincaye (second from left) became Steve Saint's mentor after Nate Saint's death.

ECUADOR



➤ **I REALLY WISH I'D BUCKLED IN.** I'm sliding all over the back seat of the Maverick while I-TEC administrator Troy Townsend whips the buggy left, then right, at 50 mph, wheels kicking up sand, to demonstrate the vehicle's agility. Thin, with a preternatural calm, the 42-year-old Townsend is Saint's fellow test pilot—as staid “as a CPA,” jokes Saint, “until you get him in something with a motor.” Townsend fractured his heel last year trying mast designs on a powered parachute, then emergency-landed the flying dune buggy when the drive belt snapped during a short test flight. “We’ll keep breaking the Maverick,” he says, after we’ve parked the vehicle and I’ve scraped the gnats off my teeth. “We’ll find the weak spots, and then we’ll fix them.”

In the hanger that I-TEC calls home, Townsend and Dyck, an old friend of Saint's and a self-taught engineer,

pop an aluminum panel off the front of the buggy's chromoly tube frame to show off the innovative hydraulic steering system. It allows the steering wheel to turn the wheels while in road mode, then flare the canopy wing tips for turning in the air. Another first is the 22-foot hinged mast that holds the ram-air chute aloft for quick, safe takeoffs. And the Subaru engine's splined driveshaft can be shifted from wheel drive to fan drive by pulling a cotter pin and slipping a lever.

“We’re working on the easy button,” Dyck says. The idea is to shift to flying mode without ever leaving the

driver's seat. In addition to the Huaorani, the Maverick may serve missionaries around the world, as well as farmers and ranchers, pipeline inspection crews, hunters—anyone with a lot of rugged ground to cover.

Technology aside, not everyone is a fan of I-TEC's work. Andy Drumm, president of a Quito, Ecuador-based travel company called Tropic Journeys in Nature, thinks the Maverick “sounds innovative and potentially applicable” to the Amazon, but he has larger concerns. Drumm, a native of Wales who lives in Arlington, Va., has spent the past 15 years helping Huaorani communities support themselves through ecotourism. “The religious fundamentalists' support seems conditional on the Huaorani adopting Christianity,” he says. “I’ve seen how evangelists have opened up territory with airstrips and worked hand-in-glove with the



PHOTOGRAPH BY **BRAD DECECCO**

oil companies that exploit the indigenous people."

Saint acknowledges that he is out to promote his faith, but he says that he is a new kind of missionary. Instead of crates of Bibles in the hangar, I see boxes of reading glasses and a patented dental chair equipped with a solar-powered drill that can be carried in a backpack. I-TEC trains indigenous people to use the equipment to do basic dentistry. There's also a pair of large crates containing the fuselage and wing of a Van's RV-10 kit airplane. They were shipped from Shell Mera, where I-TEC runs a builder-assist program to give indigenous people, including the Huaorani, jobs helping U.S. amateurs build kit planes. It's all part of what Saint calls his "engineering ministry."

> AFTER NATE SAINT WAS KILLED, Marj moved with her children to Quito, Ecuador's capital, but Nate's older sister, Rachel, remained in her outpost on the edge of the jungle, still committed to missionary work. "I thought, you've got to be kidding," Steve recalls. "They killed my dad, and now they're going to kill my Aunt Rachel."

Remarkably, within three years, Rachel Saint had moved into a Huaorani village on the Tiwaeno River, and her neighbors had begun adopting Christianity. When he was 9 years old, Steve started flying into the remote area during long school breaks and befriending Huaorani children, who used the rain forest as their playground. By that time, a strange thing had happened. "I was thinking, I've got to know these people who were so special that my dad was willing to die for them, my mom went on praying for them, and my aunt was willing to risk her life to live with them," Saint says.

Another turning point in Saint's relationship with the Huaorani came a year later. Two of his companions, the sons of a hunter named Mincaye, convinced Steve to take their father's blowgun for a day of hunting. The Huaorani shared nearly everything—firewood, floor space—but a man's blowgun was his own, a precision weapon he might spend a month shaping to fit his hands. Fearful but not wanting to be left behind, Steve screwed up his courage, entered the thatched hut and took the 8-foot weapon.

As he trod through the dim light, thorns clawed at Steve's shorts and vines ensnared his feet. The boys left the trail in search of a fruiting tree where birds might feed, navigating muddy bluffs and moss-covered logs bridging ravines. At the end of the day, they returned bearing a single woodpecker. When he entered Mincaye's hut, Steve saw the barrel-chested warrior and thought, oh, no, I'm caught.

"I had been 'nettled' once," Saint says. He had ruined a dugout canoe while playing with a hatchet. "The whole community encircled me, laughing and scolding while they swatted me with the plant. The barbs set my skin on fire. If that was good for a netting, I figured taking Mincaye's blowgun really meant trouble." But Mincaye acted as if he hadn't noticed the blowgun's absence. Steve didn't understand why, but in the following months and years, Mincaye steadily drew him into

his orbit. Eventually the boy came to see the hunter and warrior as an adoptive father.

Saint's Aunt Rachel died in 1994. At the funeral, in Ecuador, Saint learned more details about his father's killing,

"YOUR NEPHEW IS TOTALLY IGNORANT," THE HUNTER HAD SAID. THE BOY COULD NOT TRACK ANIMALS, SHOOT A BLOWGUN OR EVEN MAKE A FIRE WITH STICKS. "WHO'S GOING TO TEACH HIM HOW TO LIVE?"

but the full story became clear only a dozen years later, after Marj Saint, too, had passed away. Among her papers, Steve's sister found a letter Rachel had written in the early 1960s. It described a conversation she'd had with Mincaye. "Your nephew is totally ignorant," the hunter had said. The boy could not track animals, make poison

darts, shoot a blowgun or even start a fire with sticks. "Who's going to teach him how to live?"

Rachel replied, "You, having spear-killed his father, who do you say should teach him how to live?"

"It is true," Mincaye said. "Having spear-killed his father, I myself will teach him how to live."

> AFTER HIS AUNT DIED, Saint began to feel the tug of the old family trade. He sold his share of the mining business and uprooted his family to help Mincaye and other Huaorani build their own airstrip. In 18 months, he flew more than 3300 flights in a patched-up Cessna 172, shuttling people and supplies. But the Huaorani wanted more.

"When your father came, he went fast from place to place," Mincaye told him. "In your plane you go fast from place to place. We ourselves want to go fast from place to place." Fifty years after Nunkiwi flew briefly with Nate Saint, Steve taught Nunkiwi's son Tementa to operate a powered parachute. Soon Tementa saved a life by evacuating a boy who had been bitten by a lethal fer-de-lance snake.

The day after the Maverick's test flight, Saint takes me flying. FAA rules bar me from going up in the experimental vehicle at this stage, but there are no such restrictions on Steve's shiny gold RV-10, a single-prop plane with a leather interior and digital instruments. "When I tell people I'm flying a plane built in the Ecuadorian jungle, they expect some piece of junk," Saint says proudly, his voice crackling in my headset. Then he punches it up to 200 mph, slows to 60 mph and speeds up again, climbing and banking so quickly that I grab for the dash.

Nate Saint was a daredevil as well as a dreamer, and so is Steve. In college, he used to take friends up in his Piper J-3 Cub, then charge them 10 bucks if they held on. These days, Steve rarely flies for fun. But he'll be returning to Ecuador soon, and if he's lucky he'll get some time alone in his plane. Perhaps he'll fly above the Curaray River, as he often does. But now, before returning to the ground, Saint pulls back on the stick one more time. The nose goes high and the horizon disappears. We see only the deep blue air. **PM**

◀ The Maverick has flown as high as 1000 feet and as far as 20 miles, staying in the air for half an hour. On the ground, it can go up to 80 mph.

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MAILBOX POST + BRASS
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DIY Home

Building a Backyard Oasis

HOW TO PLAN AND POST
A PERFECT PERGOLA. BY MARK CLEMENT

Mark rafter and girder intersections to ensure evenly spaced rows.

DO IT YOURSELF

I love building pergolas. To me, they're a perfect blend of big honkin' timbers, some pretty neat carpentry and a little landscaping thrown in for good measure. The simple combination of posts and open rafters is ideal

for highlighting entrances, masking storage areas, providing privacy and especially creating some shade. I built this one as a focal point for an outdoor dining area—and to reclaim an unused patch of the backyard.

Materials and Design

It's just four posts and some boards, but a pergola must stand plumb, level and square through all kinds of weather. I chose attractive, naturally rot-resistant western red cedar for this job. I've built plenty of pergolas with pressure-treated lumber too—if you go that route, just make sure the lumber is rated for ground contact. Vinyl and composites, which often come in ready-to-assemble kits, also work well.

For this project, I built a frame on the ground to mark my four posts' locations before digging. I moved the frame out of the way, dug the postholes and brought the frame back. Then I backfilled the 6 x 6 posts and fastened them to the frame.

This method works for pergolas in open lawn space. If you are building over an existing stone patio, don't anchor the structure directly to the patio. Instead, remove some stones, dig footings and weave the patio parts around the posts. To anchor to a concrete slab or footing, use post anchors like Simpson Strong-Tie's ABA66—these raise the post off the ground, letting moisture escape. When affixing to the side of the house, fasten the timbers securely to framing and flash the connection. One thing to watch out for: Tying the pergola to a deck can be dangerous. Get a permit to ensure your plans are safe. Finally, local laws require setbacks from a property line to the edge of a structure. Check building codes; at least 4 feet is typical.

As for the dimensions of the building, I never build a pergola that measures less than 80 inches from ground to girder bottom—the same as an interior doorway. Structures built too short look like mesas; too tall and they look like towers. Since the space often defines the pergola dimensions, there's no rule of thumb on length and width.

Codes don't specify spans for pergolas because they don't support weight. But span too far and the girders will "smile" as the center bends to the earth. Here, I used two 2 x 8s spanned 10 feet from post to post. To



1



2

get a bulletproof connection, I bolted through the post with double hot-dipped galvanized through-bolts. For spans greater than 14 feet I'd add angle brackets. I'd also beef the girder up to a 2 x 10 or 2 x 12. Aesthetically, cantilevers less than 12 inches long tend to look chopped off (I used 18 inches). I like a pergola to appear to expand as it rises, so I bolt each girder to the outside of the post. (Note: This is a no-no on a deck girder.) Here, I spanned rafters 16 inches on center and mounted 2 x 4 stays on top.

Construction

I budgeted two days to level and prep the site, a day to dig and set the posts, and another to mount the girders and rafters. Last, I planned a day of yard repair. That schedule might vary

The Steps

1

A Toro Dingo's 16-inch auger makes short work of straight, 40-inch-deep holes for footings, or whatever depth will reach below frost line in your climate. For drainage, pour and pack 4 inches of gravel into the holes before installing the posts.

2

To lay out posthole locations, build a 2 x 8 frame. Its inside corners mark the four posts. Dig a small trench, level the frame, then remove it to dig the holes. Next, replace the frame, set the posts and fasten them to the sides of the frame so they'll stay plumb.



Post

3 After fastening the posts to the frame, install 2 x 4 angle braces from the frame to the posts. These will keep the posts from twisting or warping before the rafters go up and lock the posts in place for backfilling. You can remove the braces later.

4 Posthole depth varies. It's best to install the posts long and trim them to final height, measuring from the frame upward. Finish the circular-saw cut with a handsaw, then install a cleat 6 inches down (inset) to hold the girders while fastening.

5 Temporarily set the girders with deck screws above the cleats, then install the through-bolts in the girders and posts. Allow the girder to rise above the post an inch or so in case you decide to run wire for lights or power.

6 Cut the rafter tails on the ground, then mark their 18-inch cantilevers against the posts. After wedging one end up top, walk the other end up the ladder. Toe-screw the rafters to the girders using a 3-inch deck screw.

7 A 2 x 4 rafter stay atop the rafters adds the right detail while holding the rafters in place. Install stays over the girders first, then over the rafters. After two coats of tinted oil-based stain, add a layer of sod, then a table and chairs.

ON THE WEB > Learn rafter-tail layout tips, get design ideas, and download classic PM pergola plans at **popularmechanics.com**.



for other builders, but there are a few universal bits of advice. First, renting an excavator saves time and effort, and also ensures the holes are straight shafts with flat bottoms. I use a 4-foot level to make sure the posts are plumb in both directions, then I anchor them to the frame. I learned this trick the hard way—posts want to move as they

dry out, and the angle brackets hold them fast until I can get the rafters and stays in place.

I detail the pergola parts on the ground before hoisting them. This eases installation and vastly increases accuracy. For example, countersink 1½-inch holes in the girders' faces to recess the bolt heads. Cut the rafter

tails on the ground, line the rafters up, and use a square to mark each rafter bottom where it will meet the girder. Mark the girder tops for rafter locations as well. Then match the marks on each piece during installation—no measuring from the ladder required. As a result, everything will go up plumb, level, straight and square.

PM

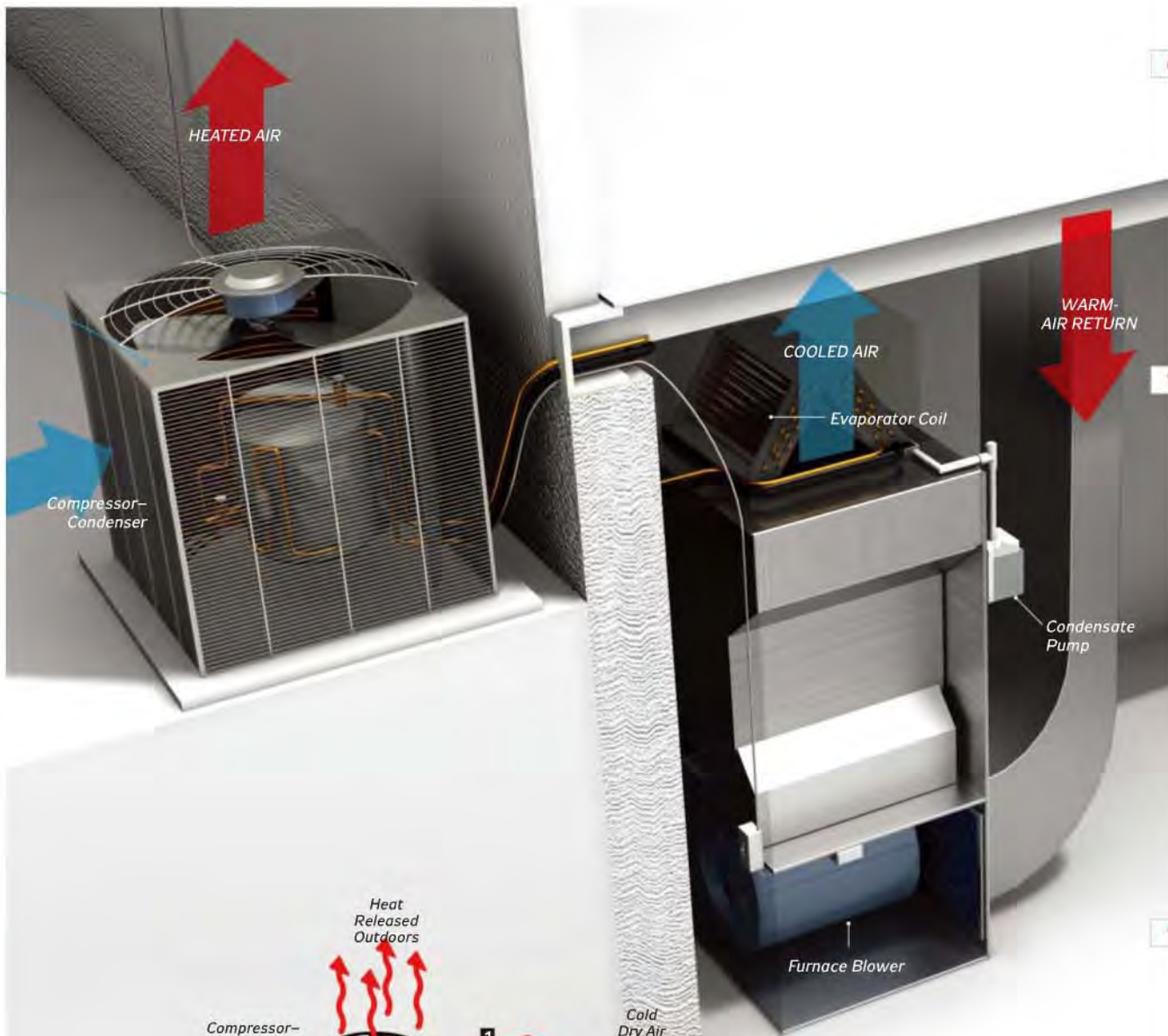
Staying Cool

KNOWING THE FACTS ABOUT CENTRAL AIR CONDITIONING CAN HELP YOU KEEP HEAT AND HUMIDITY WHERE THEY BELONG: OUTSIDE.

Like so many powerful innovations, central air conditioning is easy to take for granted. The cool, dry air that whispers unceasingly from wall and ceiling registers can lull us into a false sense of security. Then an electric bill arrives, or the system starts to falter. Suddenly we realize that basic maintenance was called for—just cleaning the air filter would have cut cooling costs 5 to 15 percent. Or perhaps it's time to replace an old and inefficient central air conditioner. There are a number of options to consider, including high-efficiency systems that can reduce electrical cooling costs 20 to 30 percent. Here's a crash course in the mechanical system that helps you keep your cool when temperatures start to climb.

by ROY BERENDSOHN
photograph by DAN CHAVKIN





THE REFRIGERATION CYCLE

Mechanical, chemical and thermal energy act together in your central air-conditioning system to cool and dehumidify indoor air. Here's how.

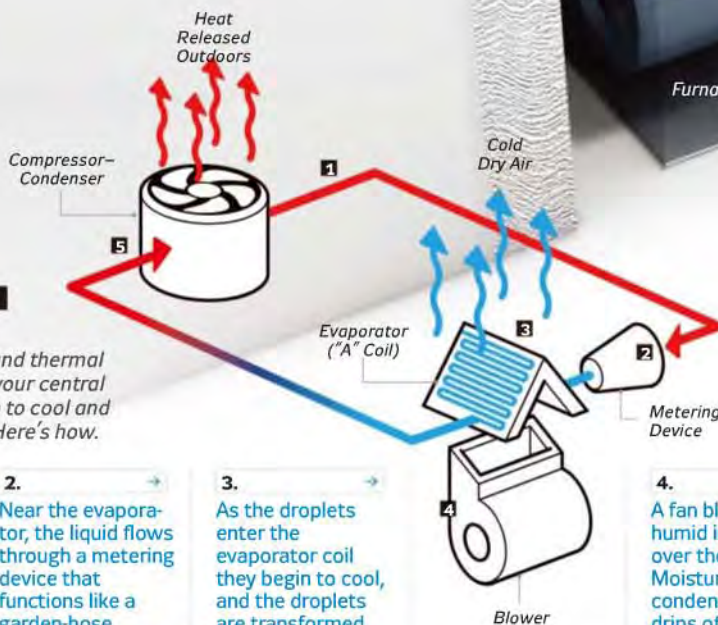
1. Warm liquid refrigerant is driven under high pressure toward the evaporator coil.

2. Near the evaporator, the liquid flows through a metering device that functions like a garden-hose nozzle. It converts the warm, high-pressure liquid into warm, low-pressure droplets.

3. As the droplets enter the evaporator coil they begin to cool, and the droplets are transformed into cold vapor.

4. A fan blows warm, humid indoor air over the cold coil. Moisture in the air condenses and drips off the coil into a pan to be drained or pumped away. The gas in the coil warms as it removes heat from the indoor air.

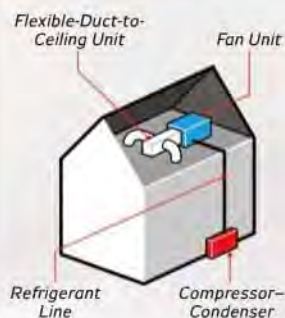
5. When the compressor turns on, it draws the warm gas toward its suction port. The gas enters as a warm vapor and leaves hot and at high pressure. Now it enters the condenser, and as it makes its way through the labyrinth of tubing, it gives up its heat to air moved by the condenser fan. The gas condenses into a warm liquid ready to repeat the cycle.



TRADITIONAL CENTRAL AIR

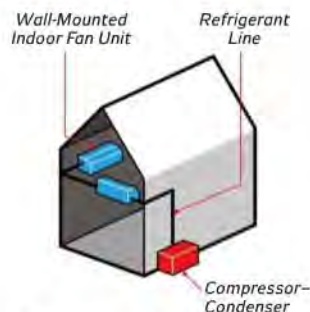
Conventional central air systems graft into a house that has ducts for forced-air heating. The hot and noisy portion of the cooling system, the compressor–condenser, is located outside. The cool and quiet component, the evaporator coil, is located inside, above the furnace blower. Cool, dry air is distributed; warm, humid air returns to be cooled and dried.

MINI-DUCT SYSTEM



Houses heated with boilers lack ducts to distribute cooled air. They can be centrally cooled with mini-duct systems in which an evaporator coil, fan and trunk duct are located in the attic. Cooled, high-velocity air is piped from the trunk duct through flexible, insulated plastic ducts.

SPLIT DUCTLESS SYSTEM



A ductless split system is the answer for many homes that are not centrally cooled or that need more cooling after an addition is built. The compressor–condenser serves one or more evaporator coil fan units installed on the inside walls of the house.

CUTTING COSTS WITH SOLAR



→ The **Lennox SunSource** is a heat pump with a solar assist. Its condenser fan motor draws power from a 190-watt photovoltaic panel, a \$3000 add-on. The high-efficiency heat pump itself costs \$4000 to \$7500, depending on the installation. The equipment runs the refrigeration cycle in reverse for winter heating, so it achieves energy gains year-round, not just in the summer cooling cycle, accelerating the energy payback of the photovoltaics. In most cases the solar panel is installed in a sunny location, either on the roof or the side of the house. Wiring then runs from the panel to the fan motor (lennox.com).

Equipment Check

THE BEST WAY TO ENSURE A STEADY FLOW OF COOL, DRY AIR THIS SUMMER IS TO DO A LITTLE BASIC MAINTENANCE THIS SPRING.

Maintaining Strong Air Flow

"The key to maintenance is air flow," according to PM contributor Pat Porzio, a heating–cooling contractor and mechanical engineer. Ensure that air can move freely through the compressor–condenser by using a shop vacuum to remove grass clippings, leaves, dryer lint and any dust discharged from a central vacuum system. If the equipment is near a dryer vent, check it weekly.

Caring for Fins

Clean dirty compressor–condenser fins using specialized foaming cleaner, sold at supply houses and on the Web. Don't use household cleaners, which can cause corrosion. Rinse the fins with a garden-hose nozzle pointed down, not horizontally, to avoid blasting dirt into the equipment. Straighten bent fins with a tool such as this fin comb (shown below), grahamtool.com.

Inside the House

- + Check the air filter monthly and replace it when necessary.
- + Keep the thermostat set at 78 F.
- + Seal leaky ducts with mastic and tape to prevent loss of cooled air and infiltration of dust and dirt into the duct system.
- + Seal gaps around the home that allow cool air to escape.
- + Open vents that were closed during the winter.



Homeowners Clinic

by Roy Berendsohn

Q + A

Post Season

Building tips for playing in the big leagues of mailbox design.



Brick House

Talk about bombproof. Use a precast concrete cap and build the pillar of standard brick and mortar mix.



Chain Mail

This is about as PM as it gets: a heavy piece of chain formed into a spiral or S-shape. Weld it with a low-hydrogen 7018 stick electrode.



Classic Wood

Cut half-laps in pressure-treated 4 x 4s with a circular saw, then clean up between the cuts with a chisel. Fasten the parts with deck screws.

The Store-Bought Option

Building a support isn't hard, but to get a mailbox in place faster, choose a ready-made, weather-resistant aluminum or vinyl post.

Mail Call

Q My mailbox and post have taken a beating, and I'm ready to replace them. What do I need to know before I start?

A Replacing a mailbox and post is a straightforward DIY project, and it contributes to a house's curb appeal. You don't need much experience to tackle it, though removing the old post can be a wrestling match, especially if it was built with a hefty concrete footing. My advice: Enlist help for the project's demolition phase.

When it comes time to build, you've got your choice of materials for the post and box support: steel, wood, wood wrapped with vinyl or aluminum, or even granite. The designs range from rugged utilitarian to fanciful. I'm always impressed by the variety I see as I drive around the rural area where I live. There's a box supported by a gigantic earth auger post, another with a heavy piece of chain welded into a surprisingly graceful S-curve, and cedar posts with flower boxes on the back of the box support. I



Homeowners Clinic

by Roy Berendsohn

Q + A

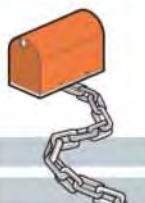
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wouldn't be surprised if the owners are PM readers.

Mailboxes see a great deal of punishment. They get buried by passing snowplows and pummeled by string trimmers. (Not to mention the occasional carload of baseball-bat-wielding hoodlums.) No wonder some homeowners opt for up-armored models built to withstand anything short of nuclear attack. But a post and box support don't have to be massive to be durable.

Use weather-resistant screws and bolts, such as those labeled HD Galv

(hot-dipped galvanized), or opt for stainless steel. If you build a steel post and box support, use a three-part paint system for maximum durability. The first primer coat should be a zinc-rich spray such as Rust-Oleum's Cold Galvanizing Compound. Follow this with an intermediate coating such as the company's Aluminum Primer, and complete the paint job with a pro-quality alkyd (oil-based) topcoat.

Lumber used for posts should be pressure-treated and rated for ground contact: The tag stapled to the product's end grain should read "End Use Ground Contact," and somewhere adjacent to that term will be "0.40 pcf," which designates the concentration of preservative used in these products. Or use western red cedar.

Refinishing Brass

I want to polish and refinish the brass hardware on my front door. What's the best way to do this so it stays shiny as long as possible?

People are becoming accustomed to seeing extremely glossy lighting, door and plumbing hardware. A lot of these products are finished with PVD (physical vapor deposition) technology. This method transforms metal vapor into a thin but extremely tough coating on a product's surface. How tough? PVD was developed for use in the aerospace industry.

I'm assuming you don't have PVD coatings on your hardware, or you wouldn't be asking the question. Although you can get good metal-finishing results with ordinary home methods, there are limits to the results you should expect. Besides, any finish you apply will need to be stripped off some day. The tougher the finish, the more difficult that job will be.

A good technique is to use an ordinary household metal cleaner like Brasso to strip the layer of tarnish off the surface of the brass. You can leave it at that or opt for a clear-coat finish. To clear coat, first remove any oily residue left from the polishing process by wiping the surface with acetone. Once the

surface has dried, apply a UV-resistant clear coating, such as Permalac EF.

Getting a Handle On Water Savings

Our toilet tank's handle sticks in the down position. Is this an easy fix?

Yes. Lift the tank lid, press the handle, and watch the lever and chain that lift the flapper valve. It may be that the lever rubs on the tank wall or the chain is excessively long and hinders the handle's return to the "up" position. Or mineral deposits could have encrusted the coupling assembly, hanging up its movement. If that's the case, scrubbing the assembly with vinegar and a toothbrush will probably clear up the problem.

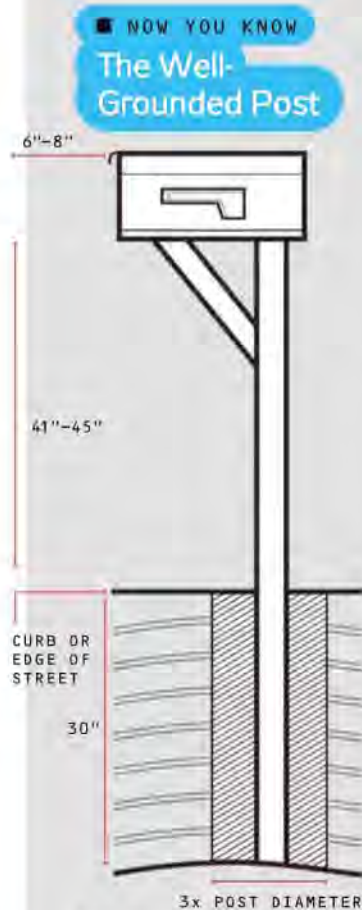
If adjustments to the lever, chain and handle don't work, install a new handle. Note that the coupling that connects the handle to the flush lever has a left-hand thread. This prevents the coupling from loosening as the handle is pressed down. Turn the nut off the old coupling and onto the new one in the opposite direction you normally would.

Railing Height

I'm building a deck. What height should I make the handrailing?

The International Residential Code, a building code that most states use, says deck handrails should be no less than 36 inches high (34 inches on stairs). That sounds simple, but your town may mandate another dimension; it may also have requirements about how the rail is built and attached to the deck. Don't make assumptions. File for a building permit and get all the information you need before you swing a hammer on the project.

PM



Neither rain, nor sleet, nor snow, nor gloom of night keeps the mail from getting through, but you have to do your part too. That means setting a new post and positioning the box so that a postal carrier can efficiently deliver mail. Your municipality or county may mandate specific dimensions, but otherwise those shown here should work.

GOT A HOME-MAINTENANCE OR REPAIR PROBLEM?

Ask Roy about it. Send your questions to pmhomeclinic@hearst.com or to Homeowners Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer questions individually, problems of general interest will be discussed in the column.

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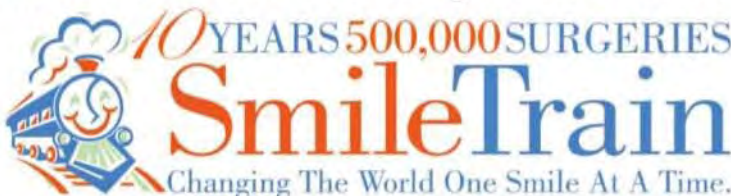
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Use a digital multi-meter set to the millivolt range to search for voltage drops.

Chasing Voltage Drops

DIAGNOSE ELECTRICAL PROBLEMS BY CHASING VOLTAGE DROPS, INSTEAD OF THE OLD-FASHIONED WAY—CHECKING CONTINUITY. *BY MIKE ALLEN*

The road ahead looks like a black hole. It's so dark and so dreary, even the bravest Saturday mechanic would prefer to be off the highway and safe at home. Unfortunately, you're still hours away from your destination. You can't see anything except the small puddle of light cast by your headlights. And that puddle seems to be getting smaller. And yellower. A quick stop at the convenience store for gasoline and a quart of carrot juice reveals the cause—one of your headlights is as yellow as Satan's toenails.

You've got a voltage drop.



Back to Basics

Electricity shouldn't be daunting, especially when it comes to automotive wiring. It's simple direct current (DC), and it doesn't pack enough punch to make your toes tingle—even if you're standing in wet sneakers. I will grant you, working on an electrical

system just isn't as intuitive as a mechanical system is. Imagine the linkage to a carburetor. Remember carburetors? Carbs are easy to understand. If one end of the throttle linkage moves when you wiggle it and the other end doesn't, it's broken. If you wiggle one end and neither end moves, it's stuck. And if it's hard to move, it needs to be oiled. Electrical-system diagnosis, on the other hand, is one step removed—you can't see the electricity in the wire like you can see the linkage wiggling. Sure, you can do simple electrical diagnosis with nothing more than a trouble light. I have a couple of trouble lights, and I use them all the time. But diagnosing anything more complicated than a burned-out bulb calls for bigger guns. You need a voltmeter. Or, more technically, a digital multimeter, or DMM. You can get a decent one for about the price of a couple of pepperoni pizzas.

Meeting With Resistance

Back to your dim headlight. There's resistance in the circuit, reducing the voltage available at the headlamp. You can use the DMM's ohmmeter scale to find the extra resistance, right?

Wrong. We're chasing very small resistances, often smaller than a single ohm. The resistance (ohm) scale on

your DMM probably bottoms out at 200 ohms, making measurement of single-digit values tricky. Instead, use the voltage scale, which on most DMMs is accurate down to several millivolts. Let's dig in.

Start by turning on the offending circuit—in this case the headlight low beams. Now we'll measure the battery voltage. We need to know the exact number you see when metering across the battery posts. And I mean the lead posts themselves, not the clamps. It should be around 12.5 to 12.8 volts if the battery is fully charged.

Back-probe the connector on the dim headlight. The black lead on your DMM should go to a good ground—preferably to the battery negative post. The voltage you meter at the low-beam lug, as it turns out, is about 11 volts. That's lower than our system

voltage at about 12.5—but not low enough to explain the severe dim-out. Now probe the *ground* lug at the bulb connector. Surprise! The meter reads nearly 4 volts—it should read zero. This indicates a resistance in the ground side of the wiring, leaving only 7 volts for the filament.

First lesson: Electricity always runs in a circle, and the ground side is just as important as the hot side.

Second lesson: Use a little systems analysis. Only one headlamp is dim, so you can skip troubleshooting any part of the circuit that's shared with the one that's working.

As you're metering the ground side, suddenly the voltage on the meter jumps up. And it doesn't jump to the 11 volts we saw before—it jumps right up to 12.5 volts, exactly what we can meter at the battery. The bulb goes out at the same instant. Now what?

You're metering full battery voltage. That means there is lack of continuity—an "open" in the circuit somewhere

Circuit-Tracing Tips

1 Blade-type fuses have test points on top, a good place to meter the voltage in a circuit. Try this: Meter both test points on the millivolt range, and read the voltage drop across the fuse. No voltage? Then there's no current flowing.

2 Never insert the meter probe into the female end of a wiring connector. It's easy to damage the contacts. Instead, probe from the back of the connector, where the wires are inserted. It's called back-probing.

3 Chase voltage drops along the circuit path from hot to ground, as in this trailer connector. Here we're looking for voltage drop between the plug and the wire to the running lights.



between the DMM positive probe and the battery ground. If the open resulted from a burned-out filament or a broken wire on the hot side, you'd see zero volts. The open is on the ground side for sure. What used to be a resistance, around 1 ohm, in that ground circuit has suddenly become an open, with essentially infinite resistance. Culprit? It's a broken ground wire, probably caused by someone poking a pointy test light or meter probe through the wiring to examine a problem years ago. The hole in the insulation has admitted water to the wire inside, turning it into green, high-resistance corrosion—eventually causing the wire to fail.

Which brings up another lesson: Never poke a hole into a wire to check a circuit. So, you replace the wire. Problem solved; at least until you go around front to check the lights. Now they're both the same color. Perking up the dim one suddenly makes you realize they're both less than brilliant—which is what I'd expect when I meter 11 volts at the bulb socket instead of the 14 I'd expect when the engine is running. There's *still* a resistance in the circuit, but this time it's between the battery and bulb. Back to the DMM.

Meter between the battery positive post and the clamp. You should see very little voltage there. With the lights up, the total draw on the battery is 15 amps or more. Any resistance between the clamp and the post will cause a measurable voltage drop. It shouldn't be more than a few millivolts. Chase the circuit toward the lamp, one metal-to-metal junction at a time. Probing between the input and output of the headlamp relay shows a drop of nearly a volt. Popping in a new relay puts that reading down to a few millivolts. And both headlamps are blazing. Problem solved.

Warning: Math Alert

Your 55-watt headlamp bulb draws 4 to 5 amps from the car's electrical system, and we can calculate that it has a resistance of about 3 ohms. Our cheapo trouble light has a resistance of 10 to 12 ohms, meaning that if we poke the trouble-light probe into a circuit, it becomes part of the circuit, changing the values we're trying to

■ PHYSICS 101

Ohm's Law

First rule of working on an automotive electrical system: It's only 12 volts, and you can't get a shock. (Well, except maybe from the spark plug wiring, but I digress.) Second rule: The second rule isn't just a rule—it's the law. Specifically, Ohm's law. Don't freak; I'll go slow with the math.

$$I = V/R, \text{ where}$$

I = the current flowing in a circuit

V = the voltage that pushes the current

R = the resistance in the circuit

AN EXAMPLE: A headlamp low beam normally draws 4 amps or so when it's switched on. (That's the current.) The voltage is around 13 to 14 volts when the engine is running. So,

$4 = 14/R$, where R is the resistance of the filament in the bulb. Solving for R , we get $14/4$, or just under 3.5 ohms. Imagine that one headlamp is kinda yellow compared to the other side. We measure the voltage at the lamp socket, and it's only around 7 volts, explaining the dimness. I'll leave the math for homework, but that means there's another 3.5 ohms of resistance somewhere between the battery and the headlamp. The circuit, with its extra resistance, will now have a total resistance of 7 ohms for a current draw of 2 amps, and it's our mission to find that resistance and repair it. Another example: The starter motor draws 200 amps (roughly) when the engine is cranking, usually when the battery voltage is only about 10 volts. So,

$$200 = 10/R, \text{ making } R = 0.05 \text{ ohms}$$

Similarly, if we know that an electrical device has a resistance, we can figure out how much current it will draw. Installing a new set of eight clearance lights on the travel trailer? Measure one bulb with a really good ohmmeter, and it measures 12 ohms. You can figure on roughly 1 amp of current. Multiply that by 8 running lights—your new lights will draw a total of 8 amps. Add in the running lamps and the 10-amp fuse on that circuit may not be enough.

Trust me, these numbers will always work out correctly. If they don't, you're missing something.

diagnose. Our DMM has a resistance of over 10 million ohms, eliminating the possibility that attaching the meter probe will change the voltage in a circuit. It's important to do this testing with the circuit turned on and operating when you're troubleshooting. Imagine that our corroded wire was in the positive side of the headlamp circuit, not the ground side. And the battery is a little low, so you just pop the connector off the bulb and meter the socket. If the wiring is fine, you'll see full system voltage on the meter, so everything must be peachy, right? But there's our

damaged wire in there, with an internal resistance of an ohm or three. You'd expect the meter to show reduced voltage, and you'd be wrong. It's the current flowing in the circuit that produces the voltage drop. The DMM, with its megohm impedance, draws no current—and you'll read full system voltage until the circuit is loaded down.

I'm not happy with more than a few hundred millivolts of drop across any connector. The total drop in any circuit shouldn't be more than 1 volt, whether it's a dome light drawing 500 milliamps or a starter drawing 200. **PM**

Car Clinic

by Mike Allen

Q + A

Bustin' at the Seams

Q The plastic windshield-washer-fluid reservoir in my RV has a 2-inch-long crack in it. I suspect this happened last winter when the year-old water in it froze solid. The RV dealer near me has gone out of business, so I can't even order another reservoir. I tried to patch it with silicone sealant and duct tape, but the reservoir always leaks within a few days. The mechanic at the RV dealer across town says he can have it welded, but it would cost over \$100. Any suggestions?

A First suggestion: Drain and refill the windshield reservoir with fresh washer fluid—not water—in the fall, when you winterize the rest of the RV. Washer fluid has a high alcohol content and won't freeze. But you already had that figured out, right? Don't forget to spray the washers for a few seconds after filling up, until the blue stuff

Repairing Plastic Radiators



1 Remove the tank and dry it out. Clean, sand and degrease the broken tank in the vicinity of the crack.



2 Mix the epoxy thoroughly. Add a little to the top of the tank. Place the precut fiberglass cloth over the crack.



3 Add more epoxy, enough to completely saturate the fabric. You'll have a few minutes before it cures.



4 Use the disposable brush included in the kit to work the epoxy thoroughly into the fiberglass cloth.



5 This epoxy adhesive is supposed to cure in 30 minutes, but if I were fixing a pressurized radiator tank, I'd wait overnight.

comes out of the lines and nozzles.

About your reservoir, though: A hundred bucks sounds like a lot of money to fix a tank, unless all you have left is a shoebox full of parts. Those reservoirs are generally made of high-density polyethylene and are fairly easy to weld with conventional plastic-welding techniques. Silicone sealer just doesn't have the adhesive properties or the strength to hold these plastic parts together in the hot, high-vibration area underhood. That high estimate sounds like somebody really doesn't want to be bothered with pulling out the tank and ferrying it around town to get welded somewhere else.

Try this DIY fix: Go to the auto parts store and hunt down a Permatex Plastic Tank Repair Kit. Pull the cracked tank out and clean it really well with soap and water—then dry it out thoroughly. The kit has a sheet of fiberglass cloth inside, as well as a sheet of sandpaper. Rough up the surface that the cloth will

contact with the sandpaper. Now do a final degreasing with rubbing alcohol or lacquer thinner, and don't touch the surface again. Position the cloth over the sanded area. There's also a pouch of epoxy in the package. Squeeze the pouch until the two halves rupture their divider, then agitate them together for 30 seconds or so. Now you can squeeze some of the epoxy out onto the cloth. Use the disposable brush in the package to wet the fiberglass cloth with the adhesive. Add more adhesive until the cloth is completely saturated. Let this stand for a half hour to cure and you're good to go. They say that this product is so strong it will fix plastic radiator overflow tanks. These radiator tanks run much hotter than windshield-washer reservoirs and have to carry as much as 16 psi of pressure—so you know the product is tough. I bet it would work well on a cracked holding tank on your RV or boat, too. Sorry—Permatex says it won't work on plastic fuel tanks.

My Head's Spinning

I'm sure you know a lot about cars mechanically, but as far as your driving knowledge goes, I'm worried. You wrote in the January issue that locking up the rear wheels would cause a spin. Wrong, Mike: Braking the front wheels too much causes a spin. Front disc brakes are larger than rear brakes because they do the majority of the braking, not because they will prevent a spin. If preventing a spin, instead of stopping efficiency, were the major consideration in braking-system design, vehicles would have small or no front brakes.

I appreciate your concern, but your perception of the dynamics of a vehicle under braking is 180 degrees out of phase with reality.

Imagine, if you will, a vehicle with no front brakes at all. Use the rear brakes hard—hard enough to make them lock (which won't be particularly difficult, since weight will transfer to the front wheels as the vehicle starts to slow down, reducing the capability of the rear brakes). The locked rear wheels have zero directional stability: Because they aren't turning, they're essentially reduced to blocks of rubber, which will slide just as easily in any direction—right, left or backwards.

The freely spinning fronts, on the other hand, roll with virtually no resistance, as long as they're pointed in the direction they are traveling over the pavement. If you turn (or the road itself turns) the steering wheel even the slightest bit away from straight ahead, the tires will generate side forces—substantial side forces. And irregularities in the road will give the tires plenty of opportunities to acquire these small directional changes, even if you hold the steering wheel straight. Remember, these are front tires. Any lateral force from our small lateral direction change will tend to force the tire out of line further and further, until the car is pointed 90 degrees or more from its direction of travel. And you, kind, misguided sir, will have totally lost control.

Now, imagine locking the front wheels and leaving the rears to spin freely. The fronts, like the rears in my first example, have no directional

PROBLEM SOLVED

Freeze Rust Away



One of a mechanic's biggest stumbling blocks can be removing stuck fasteners. First you have to bring a tool to bear with enough torque to unfreeze the fastener, more than was used years ago to install that nut or bolt. When all else fails, reach for a torch. Iron oxide—rust—is larger than the steel it was created from, and the extra volume locks the two parts together like Super Glue. Heat, cool; heat, cool; add some penetrating oil and eventually you'll get the rust to crumble to powder and your nuts will loosen up. This procedure can be rough on heat-sensitive wires, seals and gaskets, eh? We just tried a can of Loctite Freeze & Release, which accomplishes the same thing with a blast of cold—really cold—penetrating oil. Just don't frostbite your fingers (don't ask).

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stability and will slide as easily in any direction. The spinning rears, when knocked a little out of line by driver input or road irregularities, develop side forces like the front ones did in our earlier scenario. The difference is that these side forces tend to make the rears realign themselves with the direction of the car's travel and—like the fins on a rocket or the tail of a kite—keep the vehicle pointed straight ahead. That's why cars have bigger brakes on the front wheels.

Don't believe me? Get a piece of cardboard or scrap wood and make a ramp. Use some tape or modeling clay to lock up the rear wheels of a model car, and then slide it down the ramp. It will immediately swap ends and hit the floor trunk first. Now lock the front wheels—the model will go down the ramp straight ahead. In fact, if you try this with a model that has steerable front wheels, it will still go down the ramp straight ahead even if the wheels are turned to one side.

Suspenders and Belt

My Hyundai dealer tells me that to keep my engine's warranty I must have the timing belt replaced at 60,000 miles. This is not a minor repair and is quite expensive. Do American car manufacturers, with newer engines, require timing-belt replacement at any mileage interval? In the past I have driven GM cars to well over 100,000 miles and never had a problem. All vehicles with rubber timing belts have a recom-

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mended replacement interval, somewhere between your Hyundai's 60,000 and as long as 105,000 miles, depending on the vehicle and the year. Ignore these replacement intervals at your peril, because some engines will be destroyed if this belt fails in service. When the camshafts stop turning, the valves might contact the piston crowns the next time the piston approaches top dead center. These are called interference engines. Others will simply stop running instantly without smashing the pistons into the valves. To see whether yours is an interference or noninterference engine and to check the replacement schedule, go to gates.com. Gates makes a lot of OEM and replacement timing belts. American and European manufacturers all make some vehicles with rubber timing belts rather than steel timing chains.

Zipless

How do I "grease" the plastic zippers on the windows of my Jeep Wrangler's soft-top?

I'd use silicone spray or Armor All. Apply it sparingly to avoid leaving a residue on the surrounding upholstery that can attract dirt and dust. If you use your Jeep as Jeep intended, it will get dusty. **PM**

GOT A CAR PROBLEM?

Ask Mike about it. Send your questions to pmautoclinic@hearst.com or to Car Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer questions individually, problems of general interest will be discussed in the column.

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BY GLENN DERENE

The average American cable subscriber pays more than **\$700** per year on cable subscription fees.



Times are tough, money is tight, and Americans are starting to take a long, hard look at their monthly bills. One expense, in particular, stands out: cable. It's hard to cut back on most utilities—a modern home doesn't quite run without electricity,

water or fuel, and some sort of phone seems essential, but television? Don't they broadcast that for free?

As a matter of fact, they do. And yet the average monthly cable bill in the U.S. is \$58.80—more than \$700 per year. Satellite TV generally offers a mild savings compared to cable, depending on what equipment and channels you select. But is there a way to get the range of TV content that typically comes from these services without the steep monthly fees?

Well, yes ... and no. If you're just

looking to get local channels, an ordinary antenna will do. In fact, given the level of digital compression that cable companies use to squeeze ever more channels down the pipe, an antenna may deliver a better quality signal with hi-def content.

To receive over-the-air digital television, you need a TV with a digital tuner and an antenna that receives UHF and VHF signals. Plenty of television antennas are currently marketed as HDTV antennas, but as television engineer Mark Schubert puts it: "There



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RadioShack Budget TV Antenna
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■ PROBLEM SOLVED

From Web to TV

Fancy new HDTVs have Internet hookups built right in, but there are plenty of ways to get Web video to your existing set.



Xbox 360

GAME SYSTEMS

Microsoft's Xbox 360 streams Netflix and sells TV shows through its Xbox Live service. Sony's PS3 has movies and shows for rent. But both gaming consoles are limited to content approved by their parent companies.



Samsung BD-P1500

BLU-RAY PLAYERS

Players from Samsung and LG have integrated Netflix streaming. As yet, no Blu-ray players offer support for online TV sources, but many players are firmware updatable, so stay tuned.



Roku Player

STAND-ALONE PLAYERS

Roku's video-streaming box plays content from Netflix and Amazon. Apple TV users can purchase content from the iTunes Store or tap into free, Web-based content by installing open-source Boxee software (which will violate their warranty).

is no such thing as an HDTV antenna." That doesn't mean that all antennas are the same. Weak digital signals, unlike weak analog signals, don't show up with static—they don't show up at all. So if you live in an area with sub-standard reception, it may be worth it to buy an amplified antenna to boost signal. Check out antennaweb.org to get an idea of what stations to expect, based on your address.

Variety-Packed

Okay, that takes care of local channels, but cable offers hundreds. What about ESPN? CNN? HBO? What about video on demand? Can you replace those once the coaxial cable is cut? The honest answer is that, if you love surfing through an endless series of channels, then nothing will truly replace cable. But according to a 2007 Nielsen study, the average American household received 104 channels—and watched only 15 of them regularly. So if statistics are any measure, a broad selection of content is important to viewers, but sheer quantity is not.

A surprising amount of TV and movie content is now available over the Internet for free or for a nominal price. The richest and most impressive source of Internet video, aside from outright torrent theft, is Netflix's "Watch Instantly." This streaming video service is a freebie extra for anyone who subscribes to the company's DVD-by-mail service (any plan over \$8.99 per month offers unlimited streaming of content). Watch Instantly lets users browse through a library of 12,000 movies and television shows, much as they would surf channels on a cable box. It nicely combines the joy of serendipitous movie discovery that comes from watching HBO or Showtime with the impulse entertainment of video on demand.

Most major networks and cable channels offer a deep reservoir of content that can be streamed over the Internet. CNN's site posts video feeds of breaking news, and ESPN has partnerships with various Internet providers around the country to offer its ESPN360 live sports streaming ser-

vice. New episodes of popular TV shows such as *Lost* and *24* are usually up on network sites within a day. NBC and Fox have teamed up to create the site hulu.com, which has so many shows and movies available for streaming that it is beginning to resemble a separate network itself.

Magic Boxes

Internet streaming video is great, but how do you get all that cable-obviating goodness onto the big-screen TV in the living room? Many new digital TVs from manufacturers such as Samsung, Sony, Panasonic and Vizio come with Internet hookups that can directly link to sources such as Netflix and YouTube. Also, Dell and HP sell computers under \$500 with HDMI outputs that can be hooked up directly to a TV.

In addition to full-featured PCs, there are a variety of Internet-enabled boxes that can be tricked out to tap into one or more of these sources. The Microsoft Xbox 360 can show streaming Netflix movies with a \$50 yearly Xbox Live subscription. Perhaps the most elegant add-on device is the \$99 Roku video-streaming box. It has built-in Wi-Fi and is a snap to set up and use. Roku streams Netflix movies and video-on-demand from Amazon, which has both free and rentable content.

Which brings us to the big question: How much do you really save out of all this? To take full advantage of online content, you'll need to have an Internet connection of at least 1.5 megabits per second (expect to pay at least \$30 per month for that). And if you don't have a computer that hooks up easily to your TV, you can quickly find yourself stacking various set-top boxes at \$100 to \$300 each to get the selection of content you like. If you really go crazy with this stuff, you can burn through enough time, money and trouble that you might look back on your cable box with longing. On the other hand, if you're taking advantage of equipment and services you already have, there's a double sense of satisfaction to telling a monopolistic service provider to take a hike, combined with cash back in your pocket. That more than makes up for the loss of The Jewelry Channel.

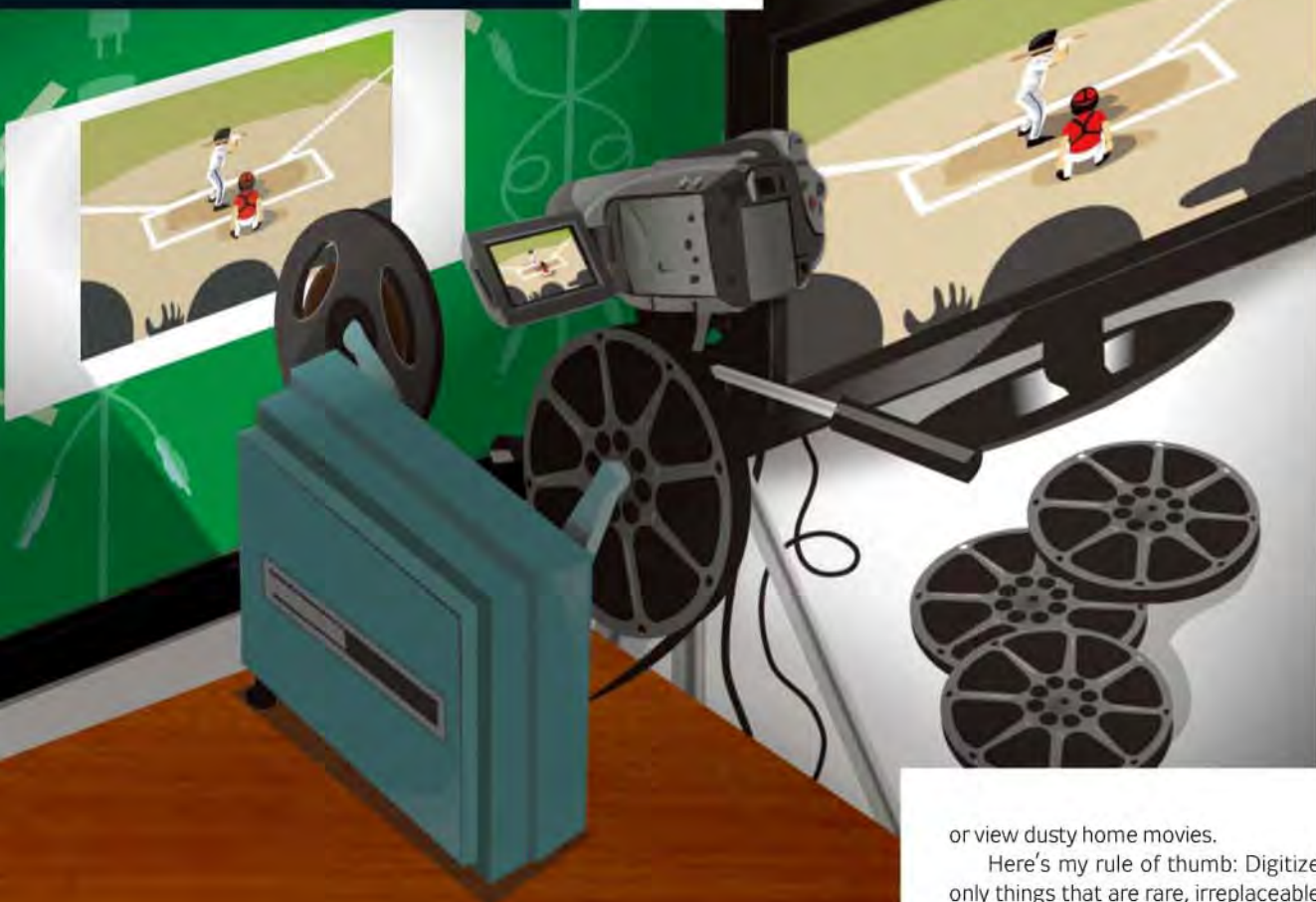


Vinyl • Cassettes • VHS • 8 mm

Digital Clinic

by Seth Porges

Q + A



Your Digital Transition

Q I have a lot of old analog music and movies that I want to preserve. What's the best way to transfer them to digital?

A Entropy conquers all analog media, forcing records and video to slowly crumble, warp and fade—threatening memories and music with oblivion. Digitizing these treasures can ensure that, no matter what mischief takes place in the attic, the good stuff will endure in an easy-to-copy format.

But before you go about the tedious task of digitizing a massive record or VHS collection, ask yourself

whether it's worth it. In many cases, it's impossible to digitize media in faster-than-real time. If you have hundreds of LPs, this can take days. And if something is readily available in a digital format, chances are that the professionally made version will look or sound a lot better than any copy you can produce. That being said, digitizing analog media can be a lot of fun. It's a great excuse to go through old records

or view dusty home movies.

Here's my rule of thumb: Digitize only things that are rare, irreplaceable or deeply personal. The footage of your kid's first steps? Back it up. A much-played VHS copy of *It's a Wonderful Life*? Toss it and buy the DVD.



Music: I've got a large collection of vinyl LPs—mostly hand-me-downs from my father. And while most of these records are readily available as MP3s or CDs—Bob Dylan, Simon and Garfunkel—a few of them will never find their way onto iTunes. A vinyl recording of my father's performance in the 1962 New Jersey State High School Orchestra, for example—this I want to digitize.

For records, the process is straightforward. Plug the turntable into an

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audio amplifier (this is typically done through dual red and white RCA jacks), then plug the amp into a computer's sound input jack using an RCA-to-headphone cord. (The RCA end goes into the amp's output slot, and the headphone jack into the computer's audio input jack.)

To save music from the LP to your computer, you'll need an audio-editing program. I like Audacity. It's free and it's easy to use. Just turn the turntable on and click the Line In button in the program. To save the songs, click on File, then Export, and choose a name and file format for your tracks.

The process for converting other analog audio is almost identical—swap in a cassette or eight-track player for the turntable.

Some newer record players even have a USB output that plugs directly into the computer. Others make it still easier: The new Ion Audio LP Dock has a built-in iPod dock that transfers vinyl directly to an MP3 player—no PC required.



VHS: If you want to digitize VHS movies, you have several options. Using a professional service to transfer home movies to DVD is fairly inexpensive—often it costs as little as \$20 per tape—but the job is also easy to do yourself.

The easy way: Get a combination VHS and DVD recorder. These can be found for under \$100; they allow users to easily transfer their movies without a TV or PC hookup—just put in the old tape, pop a blank DVD-R in the DVD recorder, hit play on the VHS side and record on the DVD side. That's it.

The slightly harder way: Plug a VCR into a device that allows it to connect to a computer, and then record the footage using a video-editing program. This device can be either an internal video-capture card, an external video-capture device or a camcorder. Using a yellow composite

video cable or S-video cable, connect the VCR to the capture device's input jack. Open a video-editing program, such as Windows Movie Maker or iMovie, then hit the play button on the VCR and Record in the program. Once the video is saved on a PC, it can easily be burned to a DVD or uploaded to the Web.



Reel-to-Reel: Many people's oldest and most treasured videos aren't videos at all—they are movies recorded on 8 mm. And while professional services can digitize these for you, the fees tend to be very high—usually several hundred dollars per reel. So it may be best to copy these yourself. The quality won't quite equal the professionals', but with proper preparation, it can be good.

Digitizing film yourself means going pirate: Project your film onto a wall, and record the images using a camcorder. Of course, anybody who has ever glimpsed a bootleg movie knows that this method has its problems—even if you don't need to worry about noisy moviegoers and their silhouettes, it's still an uphill battle against poor picture quality.

For best results, you'll need the following equipment: a variable-speed reel-to-reel projector, a camcorder, a tripod and a TV. One thing you don't need is an expensive projection screen—a piece of poster board taped to the wall will do.

It's best to do this at night, in the darkest room you have. Lower shades, turn off lights and do all you can to minimize ambient light.

Slowly tweak the projector's speed until there is no flickering in the camcorder's picture. Adjust the projector so that the picture is in focus and a bit more than a foot tall (the smaller the image, the more detail it keeps), then mount the camcorder on its tripod and connect it to a TV so that the screen acts as a giant viewfinder. Place the camera near the projector so that the angle

is as close to straight-on as possible, but doesn't interfere with the view. Then, zoom in on the picture so that it precisely fills the frame. Manually focus the camcorder's image—the autofocus could cause it to drift in and out of focus during the projection.

If the movie is silent, be sure to mute the microphone on the camcorder. If there is sound, connect the audio output of the projector directly to the camcorder's audio input.

And, of course, don't be afraid to try several takes until you produce a movie you're happy with.

Ripple Effect

When I touch my LCD monitor, it causes a rippling distortion in the image. Can this damage my screen?

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Ask Seth about it. Send your questions to pmdigitalclinic@hearst.com or to Digital Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer every question individually, problems of general interest will be discussed in the column.



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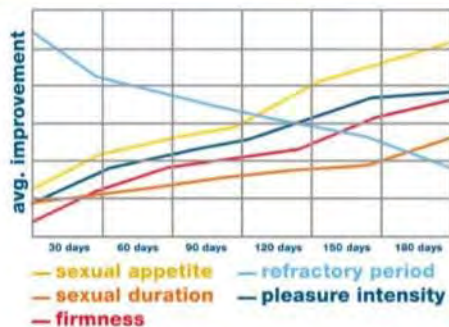
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THIS IS MY JOB

ENGINE RESEARCHER

> STANI BOHAC
> ANN ARBOR, MICH.
> AGE: 38
> YEARS ON JOB: 6

1. Diesel Test Engine

Bohac runs dozens of experiments on a stationary test engine, using sensors to measure everything from intake air temperature to cylinder pressure.

2. Cylinder Pressure Transducer

Controlling combustion is one way to affect emission output; this transducer determines combustion quality.

3. Diesel Oxidation Catalysts

An internal honeycomb coated with a catalyst reacts with engine exhaust to break down carbon monoxide and hydrocarbons. Bohac experiments with platinum, rhodium and palladium to try to increase effectiveness.

4. Capillary Column

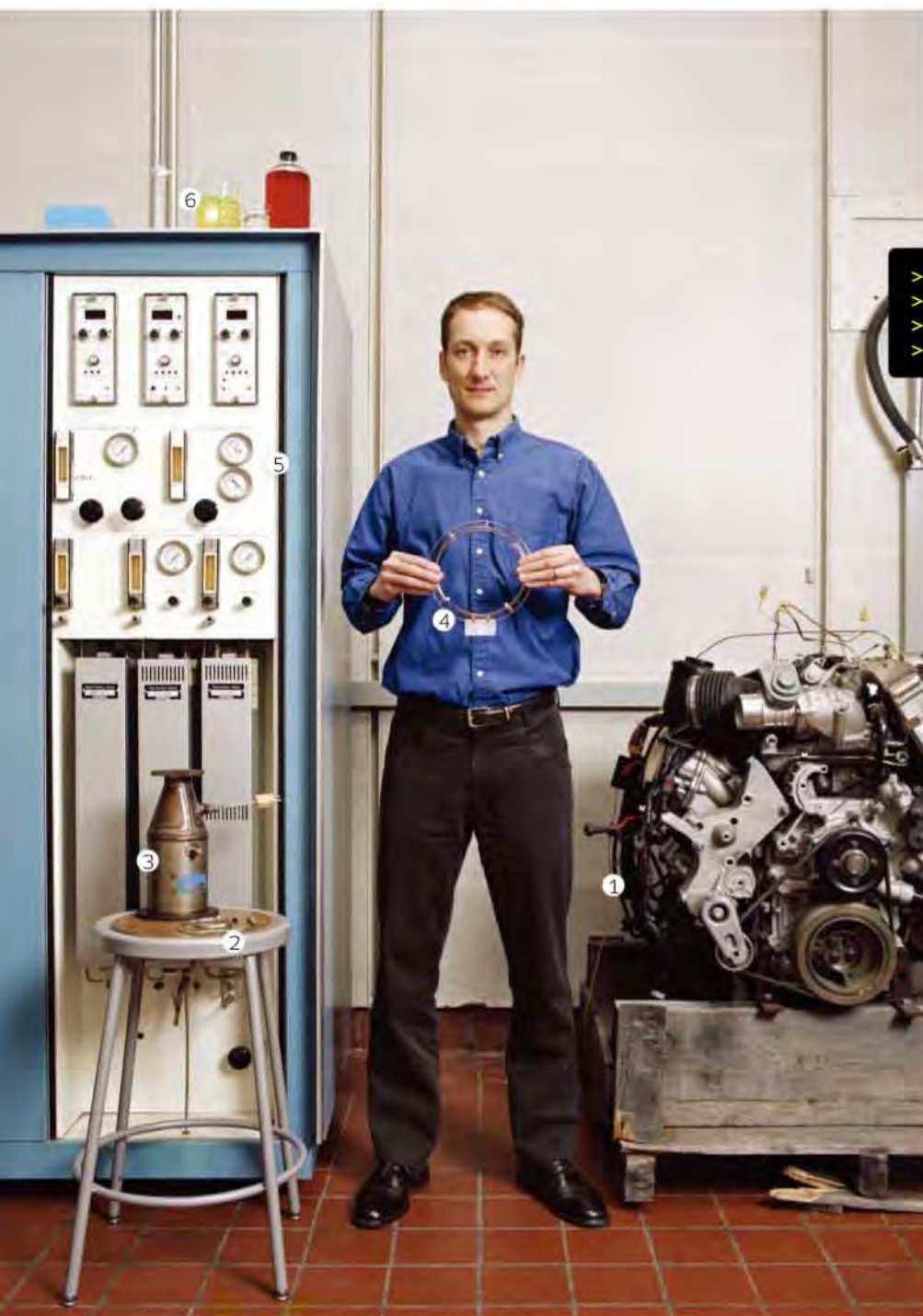
Coatings on the inside of this tube sort the hydrocarbons emitted by combustion; a gas chromatograph detects the type and amount of compounds.

5. Exhaust Gas Analyzer

The exhaust chemical cocktail is a ratio of hydrocarbons, oxides of nitrogen, carbon dioxide and monoxide, oxygen and particulates. The ratio of these compounds determines how air/fuel mixtures burned.

6. Alternative Fuels

Emissions are affected by the fuel used. Bohac investigates alternatives such as biodiesel or diesel and gasoline blends.



X If future cars still use internal-combustion engines, we'll have researchers like Stani Bohac to thank. The mechanical engineer works the labs at the University of Michigan to devise cleaner, more efficient and more affordable automotive engines. Everything from alternative fuels to efficient engine design to simpler exhaust treatment is up for investigation. His team is currently conducting experiments to see if dramatically lowering diesel combustion temperatures can reduce both nitrogen oxide and particulate production. "The internal-combustion engine has been around for 100 years," Bohac says. "But we're still learning things." — LARRY WEBSTER

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